



# ADAPTATION MASTER PLAN

City of Jersey City  
Hudson County, New Jersey

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Prepared by:



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## I. Executive Summary

The Adaptation Master Plan is an effort to identify implementation measures that will improve the flood resiliency of Jersey City. This Plan is the second in a six-part series of documents, following a Resiliency Master Plan which provides an analysis of the existing flood-related conditions in Jersey City and the goals that the City has established to make itself more resilient, and preceding an Urban Environmental Green Infrastructure Design Plan which sets forth recommendations for future greening of the City and means by which to address the threat of future flooding from storm events and sea level rise. The scope of this document is such that both infrastructure projects and additional research or plan preparation (administrative measures) is recommended in order to maximize the eventual resiliency of Jersey City.

Jersey City has established its own goals and priorities, which this report recognizes as a guiding factor in all adaptation decisions. Jersey City also has distinct geographies which vary along the length of the coastlines and along the ridge of the Palisades. The Resiliency Master Plan evaluated the hydrology of the City and established Watershed Districts which have unique risks and opportunities based on sea level rise, flood risk, and topography. These were layered with social and economic vulnerabilities, making it possible to prioritize areas of Jersey City most in need of attention and where flood intervention will be most effective. These areas of the City are herein referred to as Priority Areas.

With these Districts and Areas in mind, this report evaluates prior recommendations to determine their appropriateness and feasibility. Although existing studies prepared by other agencies and experts have made many recommendations on a general scale, the need to understand how these solutions apply to Jersey City and its social, political, and geographic nuances, remained. This Adaptation Master Plan addresses these weaknesses by taking the urban pedestrian fabric of Jersey City neighborhoods, the priority of waterfront access, and the valuable infrastructure servicing Jersey City and the entire metropolitan area into account when determining what adaptation applications are locally appropriate. Public comment and surveys were also employed to best understand the needs and concerns of the community.

This report undertakes a cost-benefit analysis of prior recommendations based on the Priority Areas, Watershed Districts, and local goals, and identifies adaptation measures for each of the six Priority Areas. Solutions recommended range from street levees and elevated walkways to smaller scale solutions including deployable barriers and berms, all based on variables including existing conditions and neighborhood context, already-planned projects, and cost.

This Adaptation Master Plan focuses on more substantial physical and infrastructure measures not captured in the Green Infrastructure plan, such as levees and raising at grade elevation in strategic locations so as to protect key infrastructure, neighborhoods, and the City as a whole. However, this

plan also recommends citywide adaptation measures, including floodproofing, zoning changes, plan updates and analyses, and federal programs which may be beneficial.

Overall, the approach for Adaptation in Jersey City is multi-layered, as it is clear that no one approach will address all of the City's vulnerabilities. Given the size of Jersey City, the various locations of the Priority Areas, and the natural and man-made challenges present, each approach has been uniquely tailored, balancing cost, realistic potential of development in the short- and long-term, and the nuances of each area.

This report concludes with a list of sources for financial leverage and assistance in undertaking these recommendations.

## II. Project Background

### Historical Background

The waterfront has played a major role in defining the history and growth of Jersey City. From its economic attractiveness for port facilities, factories, and now white collar industries as well as luxury residential living, Jersey City greatly benefits from its waterfront location. Going forward, it is the waterfront areas along the Hudson and Hackensack Rivers that also face the greatest potential threats.

In 2012, Superstorm Sandy exposed the great risks to Jersey City from flooding. The high-water mark measured over 11 feet in some areas, and more than 40 percent of the City's land area was inundated during the storm.<sup>1,2</sup> However, the damage to the City went beyond flooding. Some of the adverse impacts experienced by the City are the following:



Figure 1: 1883 vintage cartograph of Jersey City waterfront

<sup>1</sup> *Sandy Recovery Strategic Planning Report – A Strategic Plan for Resilience*, prepared by the City of Jersey City Planning Department; dated August 2014; page 6.

<sup>2</sup> Includes addition of Country Village Land Area missing from USGS Sandy inundation Maps.

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1. Personal property damage, with the Federal Emergency Management Agency (FEMA) approving over \$11 million in housing related claims.<sup>3</sup>
2. Damage to critical facilities, including but not limited to City Hall and Jersey City Medical Center.
3. Tax ratable losses of over \$12 million.<sup>4</sup>
4. Power loss for longer than one week for some customers, as well as damage to three power substations.
5. Transportation services such as PATH and the Hudson-Bergen Light Rail suffered longer-term damage in addition to immediate service suspension.

This list is by no means exhaustive or complete. It serves to illustrate the vulnerability that Jersey City faces given its waterfront location and the large amount of its land area that is subject to flooding.

Jersey City has 3,782 acres (40 percent of the City) within the proposed FEMA Special Flood Hazard Area (SFHA).<sup>5</sup> The one percent annual chance floodplain area, formerly referred to as the 100-year flood zone, refers to an area that is expected to be inundated by a flood event with a one percent annual chance of being equaled or exceeded in any given year. Within the SFHA are high, medium, and low density residential neighborhoods, high rise office buildings, mixed use developments, commercial establishments, industrial and port areas, and many municipal facilities. Bearing in mind the significant impacts outlined above following Superstorm Sandy, Jersey City has begun the process of identifying flooding reduction strategies that consider potential sea level rise and the ongoing threat of natural events.



Figure 2: Hurricane Sandy flooding in downtown Jersey City, 2012 (*Lauren Casselberry, The Jersey Journal, 11/3/14*).

<sup>3</sup> *Sandy Recovery Strategic Planning Report – A Strategic Plan for Resilience*, prepared by the City of Jersey City Planning Department; dated August 2014; page 6.

<sup>4</sup> *Sandy Recovery Strategic Planning Report – A Strategic Plan for Resilience*, prepared by the City of Jersey City Planning Department; dated August 2014; page 6.

<sup>5</sup> *Sandy Recovery Strategic Planning Report – A Strategic Plan for Resilience*, prepared by the City of Jersey City Planning Department; dated August 2014; page 9.

### Post-Sandy Assessment Process

Throughout the post-Sandy recovery process, the City has committed to identifying flood reduction strategies, which includes taking account of potential sea level rise in addition to the existing vulnerabilities from storms and flood inundation. Using both State and Federal grant funding, the City of Jersey City worked on two separate but interrelated studies that assessed the City's vulnerability to flooding and outlined potential strategies for becoming more resilient. The first of these, the *Collaborative Climate Adaptation Planning for Urban Coastal Flooding* (CCAPUCF) study, a partnership between the City and Stevens Institute of Technology, mapped the effect of projected sea level rise and storm surge on one percent annual chance flood hazard areas and identified 27 potential coastal protection measures that would mitigate storm surge.

The assumptions considered for these adaptation measures were as follows:

1. Vertical solutions are proposed to specifically focus on storm surge hazards only.
2. Measures are permanent and passive, as opposed to deployable assets that may need additional personnel or equipment deployment to be effective.
3. No measures are recommended to be located on the Hudson River waterfront. The measures proposed are designed to incorporate already existing higher elevation areas and avoid the need for higher elevation designs to address potential wave impacts.
4. Limited consideration is given to socio-political factors or engineering feasibility.
5. Measures are to be situated in areas under City jurisdiction, as opposed to neighboring municipalities or under the New Jersey Sports and Exposition Authority (Meadowlands) jurisdiction.

The second study, the *Visualizations of Adaptation Scenarios and Next Steps White Paper* ("The Baker Report"), prepared by Michael Baker International, attempted to make the measures identified in the CCAPUCF report understandable to the public through graphic illustrations and conceptual renderings.

Until now, there has not been a comprehensive review to determine if any of the adaptation measures discussed in CCAPUCF or the *Visualizations* white paper are feasible. Before any recommendations are considered for implementation, Jersey City must eliminate infeasible measures and



streamline cost-benefit analysis/future infrastructure applications. This Adaptation Master Plan evaluates the feasibility of these measures, identifies any gaps in the analysis, and studies the costs and effectiveness of the solutions put forth in order to understand what measures will be most viable and likely to succeed.

### III. Project Approach

To go beyond the scope of these prior studies, this report seeks to evaluate their recommendations under a lens of local feasibility and effectiveness. The city has its own set of goals and objectives for addressing resiliency, and each neighborhood or community therein also has unique characteristics and priorities which may make some measures more realistic than others. Different areas of the city also have distinct hydrologic conditions which create opportunities for flood protection implementation, or challenges which must be acknowledged.

#### Needs Assessment - Filling the Gaps

As discussed in the 2017 Jersey City Resiliency Master Plan, prior studies offered a comprehensive analysis of the history of flooding, existing conditions, and predications for future sea level rise. The studies also provided adaptation measures to reduce the impacts of future flooding. However, the recommendations were generally broad solutions without considering local constraints, feasibility issues, and cost.

This Adaptation Master Plan seeks to fill these gaps by evaluating specific adaptation recommendations with these considerations in mind.

#### Prioritizing Vulnerable Districts

As discussed in the Resiliency Master Plan, the identification and prioritization of vulnerable districts citywide is a necessary first step in understanding where protection measures will be most effective.

A preliminary hydrological analysis of the City and its immediate environs was conducted as a first means of classifying the City into discrete locations with contained tidal inundation vulnerabilities. FEMA and NOAA data sets for both storm surge (Hurricane Flood Zones) and sea level rise scenarios (up to 6 feet) were compiled. A diagram found in the Appendix of this document entitled “Exceedance Probability Levels and Tidal

Datums - The Battery, NY, 2016” demonstrates the impact of storm surge and sea levels.<sup>6,7</sup> High resolution topographical data were mapped to understand what portions of the City are subject to these risks, and distinct areas were then delineated by common risk levels, herein referred to as Watershed Districts. These Watershed Districts allow for localized intervention to address their own coastal inundation risks, with the expectation that providing flood resiliency along critical points within the District will protect the District as a whole. As a result, eight Watershed Districts were established. (Appendix Map 1.)

Further analysis of these Watershed Districts then serves as the basis for a flood protection element alignment plan. This alignment plan will protect the city at large against coastal inundation to a level of the 500-year storm (or about 15 feet in elevation). In calculating the 15 foot mark, a sea level rise projection of 2.5 feet<sup>8</sup> as well as a 1.6 foot of freeboard was assumed, to accommodate for the intense waves which are expected in these events.

To determine the alignment of the Coastal Protection line, high ground areas were used as anchors. These are areas that are either high enough to not require any construction, or areas that are considerably high such as to require minimal interventions. Those high grounds were then connected with alignments intended to

- Protect the majority of built assets with a priority for residential properties;
- Leave vacant and landscaped properties on the interior (protected) side as much as possible for stormwater retention;
- Leave significant areas on the floodable side for green infrastructure measures and waterfront access.

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<sup>6</sup> Tidal datums are used as references to measure local water levels. A tidal datum is a standard elevation defined by a certain phase of the tide (Low tide, Mean tide, High tide, etc.). For the purpose of this analysis for the City of Jersey City, the nearest monitoring Station that NOAA operates is in the Battery, NYC, and serves as a reliable source.

<sup>7</sup> Exceedance probability, sometimes called the annual rate of exceedance, is the number of times per unit time (year) that a random process exceeds some critical value (Mean High Water Datum for instance). To clarify, a 100 year flood is not a flood which occurs every one hundred years, but a flood that has a 1% exceedance probability of occurring every year. The probability of flood hazards changes over time, and the main contributor to an increased probability of coastal flooding is sea level rise. In addition, climate change may have an effect on increased precipitation patterns and could increase the occurrence of storm events.

<sup>8</sup> Following Hurricane Sandy, Mayor Bloomberg convened the second New York City Panel on Climate Change (NPCC2) in January 2013 to provide up-to-date scientific information and analyses on climate risks for use in the Special Initiative for Rebuilding and Resiliency (SIRR). In response to the Mayor’s charge to the Panel, the report of NPCC (2013) provides new climate change projections and future coastal flood risk maps for New York City. For this analysis, the sea level rise is decided to be set to the high estimate (90% percentile) presented in the NPCC report for the year 2050, which is equal to 0.78 m or 2.55 ft. See:

[http://www.nyc.gov/html/sirr/html/report/report.shtml?utm\\_source=buffer&utm\\_campaign=Buffer&utm\\_content=buffer2b560&utm\\_medium=twitter](http://www.nyc.gov/html/sirr/html/report/report.shtml?utm_source=buffer&utm_campaign=Buffer&utm_content=buffer2b560&utm_medium=twitter)

The flood protection improvements based on this line of protection surrounding these eight watersheds is depicted in the Appendix, *Coastal Flood Protection – Overview*, *Coastal Flood Protection – Downtown*, and *Coastal Flood Protection – West Jersey City*.

More localized sub-basins were also studied which will be critical for future detailed examination in respect to stormwater management.

### Priority Areas

The Resiliency Master Plan introduced eight **Watershed Districts** (Map 1 in the Appendix), which we repeat here, are discrete areas delineated by common hydrogeological and tidal inundation vulnerabilities:

1. Watershed District 1 - Downtown Jersey City: Includes Newport, Exchange Place, and the four Downtown historic districts. The area includes a range of residential neighborhoods, from one- and two-family dwellings to multi-family high rise residential buildings. District 1 is also a major commercial and employment center, as well as a transportation hub for PATH, the Hudson-Bergen Light Rail lines, and the Holland Tunnel. Downtown has many neighborhoods that are characterized by having a one percent annual chance flood hazard area where block groups equal or exceed the regional poverty threshold.
2. Watershed District 2 - Liberty State Park: A major recreation hub along the Hudson River waterfront, with industrial and commercial uses located at its southern portion I the Liberty harbor industrial park area.
3. Watershed District 3 - Bergen-Lafayette, Morris Canal, Communipaw: Primarily residential neighborhood west of the New Jersey Turnpike Extension (Interstate 78), which also includes industrial and neighborhood commercial land uses, and the Hudson-Bergen Light Rail line. There are Census blocks in this neighborhood that are characterized by having a one percent annual chance flood hazard area and comprising populations that equal or exceed the regional poverty threshold.
4. Watershed District 4 - Port Liberté: The Port Liberté residential development and the Liberty National Golf Course are in this District.
5. Watershed District 5 - Greenville Yards: Adjacent to the City of Bayonne, this District includes port facilities, industrial, and commercial land uses.
6. Watershed District 6 - Country Village and Society Hill: This area encompasses residential neighborhoods. Country Village is a one- and two-family residential neighborhood within the one percent annual chance flood hazard area and with block groups equal or exceed the

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regional poverty threshold. Society Hill is also a residential neighborhood, with commercial development along Route 440 east of Society Hill Drive.

7. Watershed District 7 - Westside, Lincoln Park, Marion: South of Newark Avenue and west of West Side Avenue, including the Route 440 commercial corridor. Residential neighborhoods are located east of Route 440. Many of these neighborhood census blocks are characterized by having areas with a one percent annual chance flood hazard area where the population equals or exceeds the regional poverty threshold. These areas are primarily located north of Communipaw Avenue and US Truck Route 1 & 9.
8. Watershed District 8 - Riverbend: Located in the northwest portion of Jersey City, west of Tonnelle Ave and under the NJSEA jurisdiction. Land uses include industrial, distribution, and railroads.

After mapping these eight Watershed Districts, additional GIS data was analyzed in order to identify critical infrastructure, land use, social vulnerability, environmental contamination and similar concerns, flood zones, and other factors to identify where the combined vulnerability is the greatest. The result is six areas where combined vulnerability is highest. These areas, also originally introduced in the Resiliency Master Plan, are termed as **Priority Areas** and labeled Areas A through F. A map of these priority Areas can be found in the Appendix and are again described as follows:

- A. Country Village (Priority Area A): Includes the Westside neighborhood south of Society Hill, which is in a one-percent flood zone, comprises block groups that equal or exceed the regional poverty threshold, has a combined sewer overflow, and includes Route 440. This Priority Area includes southern portion of Watershed District 6.
- B. Society Hill (Priority Area B): Located in a one-percent flood zone and includes several contaminated sites and ground water contamination. Includes Watershed District 6 and 7.
- C. Westside/Riverbend (Priority Area C): Centered on the boundary of Watershed Districts 7 and 8, this area includes critical infrastructure such as New Jersey Route 139 and US Route 1 & 9, and environmental concerns such as contaminated sites, combined sewer overflows, and surface water discharge.
- D. Mill Creek/Bergen-Lafayette/Van Vorst Park/Hamilton Park (Priority Area D): Includes portions of Watershed Districts 1, 2, and 3. The Mill Creek Redevelopment Area and Jersey City Medical Center are in this area, which is characterized by a one-percent flood zone and critical

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infrastructure. Western portions of the Van Vorst Park and Hamilton Park Historic Districts are in this Area. There is also a CSO in Area D. This area extends the length of the New Jersey Turnpike Newark Bay Extension from Morris Canal to the Hoboken border.

- E. Downtown/Exchange Place (Priority Area E): Comprises several neighborhoods, four of which are historic districts, plus numerous historic structures, bounded by the Hudson River, Jersey Avenue, the Tidewater Basin, and 10<sup>th</sup> Street.
- F. Newport (Priority Area F): Located in the northern portion of Watershed District 1, Area F includes the Newport and the Holland Tunnel approach.

The culmination of the Watersheds, Coastal Protection line, and vulnerabilities results in Appendix Map 4, which shows how each of the vulnerabilities interact with and is affected by one another. Each Watershed District can be considered to be independently protective and functional, allowing for phasing and flexibility with decision making as it concerns prioritization of investments. Further analysis of Priority Areas A and B suggest that in order to protect Area A it would be beneficial to also include Area B, treating the entirety of Watershed District 6 as a whole unit. Likewise for Priority Area E, the entirety of Watershed District 1 should be considered to protect Priority Areas D and F simultaneously.

### Feasibility and Cost-Benefit Analyses

Using both feasibility/impact criteria and the City's Resiliency Goals & Objectives, we reviewed the effectiveness of the adaptation measures recommended in the CCAPUCF study relative to their potential for success. Upon ranking the effectiveness of the adaptation measures, we reviewed the positive and negative aspects of these measures in the context of the neighborhood in which they are designated based on a wider range of factors than the original 27 potential adaptation measures.

To determine the value of different adaptation implementation, costs, fiscal and otherwise, are measured against any potential benefits. GIS data is used to determine the assessed value of flood areas, which is then measured against the determined amount of linear feet per adaptation improvement in each Priority Area. Adaptation measures whose benefits clearly outweigh their costs were retained as recommended measures.

### Creating an Implementation Action Plan

Combined, the Goals and Objectives and the Needs Assessment provide an understanding of what the city considers as its future priorities. The cost-benefit analysis helps determine which solutions should be undertaken to achieve these priorities. An Implementation Action Plan identifies strategies and timelines for effectively implementing projects.

There are several strategic efforts, many of which overlap, which together create an Implementation Action Plan. These strategies are outlined below, and are paired with recommended actions for the City to consider in the Action Plan Matrix at the end of this document.

1. **Preparedness** – With the expectation that there will be future storm events in Jersey City, a team of government officials and first responders need to be trained to organize and control the response before, during, and after the event. This includes the evacuation of residents, the staffing of safe shelters, command-control, debris removal and clean-up efforts, and the dissemination of information on numerous platforms in several languages. Additionally, other actions to be taken include informing the public prior to any crisis where they can go in case of a storm emergency, how to provide adequate protection for their pets, and where information will be made available.
2. **Public safety** – The safety of those who live, work, and travel through Jersey City is of paramount importance when determining what and how adaptation measures are implemented. This strategy includes both safety during and after a storm event, as well as the resiliency and preparedness of local hospitals, emergency services, and first responders.
3. **Critical infrastructure** – When responding to a crisis, it is also important that communications systems, power, roadways and transportation, and ports are operational during and after storm events. Streets must be passable to evacuate or bring in responders, power must be restored quickly, and all critical infrastructure brought online swiftly. Infrastructure needs to be protected from wind and water inundation to the greatest extent possible. It is essential to draft plans for adapting to circumstances where segments of services are not immediately available.
4. **Resilient Redevelopment** – As Jersey City continues to grow, future development and redevelopment needs to be undertaken with an eye on the future, informed by the past. With the expectation that sea level rise and flooding will be a continued threat, modifying zoning and building codes to require construction techniques that will reduce or eliminate damage becomes a greater priority.
5. **Stormwater Management** – Jersey City can tackle the effects of stormwater retention for major storm and flooding events, as well as for typical heavy rains and pluvial flooding that occur several times annually. Stormwater absorption and retention requirements can be imposed on new development. Existing sewer system improvements are part of the overall management plan.
6. **Property Acquisition** – In some cases, it is becoming clear that certain properties are suffering repeat flooding events. There is an incredible burden on the property owners as well as the City when this happens. Prioritizing City acquisition of chronically flood prone properties would limit this burden on the property owners. Moreover, such properties have potential to be designed as open spaces or other such uses that will absorb or hold water during future events

## IV. Feasibility Analysis of Existing Adaptation Strategies

As previously stated, the City of Jersey City previously worked on two separate but interrelated studies that assessed the City's vulnerability to flooding and outlined potential strategies for becoming more resilient. The first of these, the *Collaborative Climate Adaptation Planning for Urban Coastal Flooding* (CCAPUCF) study, a partnership between the city and Stevens Institute of Technology, mapped the effect of projected sea level rise and storm surge on one percent annual chance flood hazard areas and identified 27 potential coastal protection measures that would mitigate storm surge. The second study, the *Visualizations of Adaptation Scenarios and Next Steps White Paper* ("The Baker Report"), prepared by Michael Baker International, attempted to make the measures identified in the CCAPUCF report understandable to the public through graphic illustrations and conceptual renderings.

Three additional projects in various states of development or implementation were analyzed to determine how they would affect the resiliency of Jersey City: the filling of Long Slip Canal, the Crescent Park development project, and Hoboken's Rebuild By Design project. The first of these is the Long Slip Fill and Rail Enhancement project. This project will allow NJ Transit to improve resiliency by filling in the Long Slip Canal, a former freight barge channel located within NJ Transit's Hoboken Yard in Jersey City. By raising this area above the best available flood elevation to eliminate it as a conduit for flood water and by adding six elevated tracks, NJ Transit will be able to operate train service longer and recover more quickly from storm events.

Second, Crescent Park is a proposed mixed-use development project within the Grand Jersey Redevelopment Area that would involve raising the majority of the southern portion of the Redevelopment Area by approximately 6-9 feet above existing ground elevations. Current concept plans also call for filling in Mill Creek, which is currently a major conduit for floodwaters entering Jersey City. In its place, the project is proposing a park with a tidal marsh, which will be surrounded by a road network that will be elevated above the flood elevation to provide a barrier against tidal surges. As currently proposed, the design for the Jersey Avenue extension bridge by the New Jersey Turnpike Authority does not raise Jersey Avenue above the 100-year flood elevation. However, the Crescent Park project plans to raise Jersey Avenue to the maximum extent feasible (approximately 5-6 feet above existing grades) between the Hudson-Bergen Light Rail tracks and the bridge. Despite this, Jersey Avenue will remain a possible pathway for floodwaters to enter downtown Jersey City via Grand Street. Similarly, the nearby low-lying areas of Liberty State Park along Johnston Avenue will continue to allow tidal surges to flood properties in the Morris Canal Redevelopment Area and beyond.

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The third project that was assessed is the Rebuild By Design: Hudson River project, which attempts to comprehensively address flooding from major storm surges, high tides, and heavy rainfall events in Hoboken and surrounding areas bordering Jersey City and Weehawken. This project, led by the City of Hoboken and the NJDEP, proposes four key concepts:

1. **Resist:** a combination of hard infrastructure (such as bulkheads, floodwalls and seawalls) and soft landscaping features (such as berms and/or levees which could be used as parks) that act as barriers along the coast during exceptionally high tide and/or storm surge events;
2. **Delay:** policy recommendations, guidelines and urban green infrastructure to slow stormwater runoff;
3. **Store:** green and grey infrastructure improvements, such as bioretention basins, swales, and green roofs, that slow down and capture stormwater, and which will complement the efforts of the City of Hoboken's existing Green Infrastructure Strategic Plan; and
4. **Discharge:** enhancements to Hoboken's existing stormwater management system, including the identification and upgrading of existing stormwater/sewer lines, outfalls and pumping stations.

Resist features proposed along the southern Hoboken/northern Jersey City border are projected to reduce flooding to adjacent Jersey City properties and infrastructure.

Bearing these forthcoming efforts in mind, and adding to them Jersey City's local priorities, social vulnerability, and hydrologic conditions, the next step is to understand which of the previously recommended adaptation measures are realistic and feasible. The following criteria have been considered in the rating of the potential adaptation measures recommended in prior studies:

1. Technical feasibility. Is the potential measure buildable? If so, can it be done at a realistic cost and will it work over a long-term period?
2. Political and administrative feasibility. Is there broad enough consensus among local officials and stakeholders to support a specific measure? Is the City willing and/or does it have the capability to administer the potential measure in question?
3. Socio-economic impact. Does a potential measure have a disproportionate adverse impact on lower-income neighborhoods? Conversely, are the potential long-term benefits of such measures experienced throughout affected neighborhoods, regardless of income level?
4. Environmental feasibility. Does a specific measure consider potential adverse environmental impacts, whether related to flooding or another environmental concern that may be affected?
5. Urban design impact. Is the specific measure designed to be integrated into the surrounding land use and aesthetic pattern? If there is a distinctive aesthetic pattern, does the measure contribute in a positive way toward improving the aesthetics and design of the area?



Other considerations that have been considered in prioritizing adaptation measures include impacts to critical transportation infrastructure, small business impacts, and historic value.

Each of the adaptation measures has also been analyzed to ensure that they address the City’s Resiliency Goals and Objectives.

Using both feasibility/impact criteria and the City’s Resiliency Goals & Objectives, we reviewed the effectiveness of the adaptation measures recommended in the CCAPUCF study relative to their potential for success. Upon ranking the effectiveness of the adaptation measures, we reviewed the positive and negative aspects of these measures in the neighborhoods they are designated based on a wider range of factors than the original 27 potential adaptation measures.

A full list of all reference material used to provide information incorporated into this Adaptation Master Plan can be found in the appendix of this report.

### **Previously Recommended Adaptation Measures**

The 27 adaptation measures offered in the CCAPUCF study, and graphically represented in the “Baker Report” (see also Map of Prior Recommendations in the Appendix of this document) are distributed throughout the City and comprise five specific types of measures, as follows:

1. Earthen berm levees or embankments constructed of compacted earthen materials with no infrastructure on their crest.
2. Boardwalk levees, where barriers are constructed with boardwalks on top for pedestrian and bicycle conveyance.
3. Strategic land rise using fill.
4. Street levees where a flood protection barrier is constructed and roadway sits on top of barrier.
5. Surge barriers designed to prevent storm surge related flooding from penetrating behind barrier.

Each of the nine Watershed Districts identified in the “Prioritizing Vulnerable Districts” section above has been reviewed, and what adaptation measures, if any, were recommended in each district based on their hydrology has been determined. As seen on Map 1, the Watershed District mapping provides general recommendations for potential berm placement and higher ground areas (Map 2) that can service as anchors for such measures. This is done by connecting natural points of high elevation (“anchors”) with man-made elements to prevent water intrusion. It is

understood that water will be permitted to flood certain areas (for example, Liberty State Park), thereby allowing the wall of protection to move inland, and in some cases join high elevation anchors and reduce any visual impacts. The CCAPUCF study and the Baker Report offered the following adaptation measures for consideration, which are listed below based on the Watershed District within which they are proposed.

1. Watershed District 1: land rise, street levees, surge barrier, boardwalk levees
  - a. Land rise proposed in the Newport neighborhood at the northeast corner of the City, and at the Mill Creek Redevelopment Area.
  - b. Street levees along Washington Street and the Dudley Street area near Colgate and Paulus Hook.
  - c. Surge barrier at Morris Canal Basin (Liberty Harbor North).
  - d. Boardwalk levee along Liberty Harbor North.
2. Watershed District 2: berm levees, street levees, and land rise
  - a. Berm levees located at the north end of Liberty State Park (adjacent to Morris Canal Basin) and surrounding the industrial/commercial area at the southern end of the district with placement on park property.
  - b. Land rise proposed around Liberty Science Center site.
  - c. Street levee proposed on Phillip Street.
3. Watershed District 3: no specific measures recommended
4. Watershed District 4: boardwalk levee, surge barrier, street levee
  - a. Boardwalk levee along the Hudson River Waterfront walkway at Port Liberté.
  - b. Surge barrier at Caven Point.
  - c. Street levee on Chapel Avenue and Caven Point Road.
5. Watershed District 5: no measures recommended

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6. Watershed District 6: street levee and boardwalk levee
  - a. Street levee along Route 440 up to Communipaw Avenue.
  - b. Boardwalk levee on riverfront walkway around Society Hill.
7. Watershed District 8: land rise west of Route 440 and street levee along Route 440
8. Watershed District 9: street levee at Tonnelle Avenue

Our recommendations will focus on the adaptation measures proposed that fall within the identified Priority Areas (A through F) and their underlying Watershed District(s). Those measures, as sorted into the Priority Areas, are as follows:

1. Area A: Country Village street levee along Route 440
2. Area B: street levee and boardwalk levee
  - a. Society Hill boardwalk levee along existing riverfront walkway.
  - b. North of Society Hill land rise west of Route 440 and street levee along Route 440.
3. Area C: Tonnelle Avenue street levee
4. Area D: land rise at Mill Creek
5. Area E:
  - a. Surge barrier floodgate at Tidewater Basin
  - b. Boardwalk levee along the Hudson River Waterfront Walkway at Dudley Street.
  - c. Street levees three feet above the current grade at Dudley Street and Washington Street.
6. Area F: street levee and land rise

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- a. Street levee along Washington Street from Montgomery Street north to 14<sup>th</sup> Street.
- b. Land rise at Newport Green Park.

**Meeting the City's Resiliency Goals and Objectives**

The following Goals and Objectives were identified in the Jersey City 2017 Resiliency Master Plan. These should be considered when determining which adaptation measures are appropriate and in keeping with the City's broader vision.

**Goal:** *Create a Jersey City that is resilient against flooding*

**Objectives:**

- Protect vulnerable areas from coastal and pluvial flooding.
- Preserve and protect historic neighborhoods and structures.
- Mitigate the impacts of known sources of hazardous sediment and combined sewer outflows.
- Develop gray and green infrastructure solutions to reduce the impact of flooding events.
- Identify points of necessary infrastructure coordination with the neighboring communities.
- Minimize the impact of flood control infrastructure on existing and planned neighborhoods.

**Goal:** *Protect Jersey City's critical infrastructure*

**Objectives:**

- Plan for operational continuity of critical infrastructure networks (energy, water, sewage, mobility, medical, communications, etc.) in the case of an emergency event.

**Goal:** *Improve emergency preparedness citywide*

**Objectives:**

- Identify "resilience centers" accessible to and capable of serving residents citywide.
- Provide usable, accessible, and up-to-date online emergency resources.
- Identify City agencies and positions therein who will be responsible for providing leadership during emergencies.
- Provide emergency response training for City departments and positions therein who will be held responsible during emergencies.

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- Facilitate mobility and connectivity for ease of emergency evacuation.

**Goal:** *Create a socially resilient community*

**Objectives:**

- Maintain and expand access to the Jersey City waterfronts.
- Leverage proposed flood protection infrastructure and landscape projects to benefit all citizens of Jersey City with an emphasis on the most vulnerable communities.
- Ensure that flood protection infrastructure protects the connections between communities and the services, necessities (food, water, medical needs), and critical support needed during flood emergencies, and that no measures isolate neighborhoods or limit points of access.
- Provide equity in protection measures along both the Hackensack and Hudson River waterfronts.
- Retain and expand waterfront access for the enjoyment of the residents of and visitors to Jersey City wherever possible.

**Goal:** *Ensure economic stability against the threat of flooding*

**Objectives:**

- Reduce the economic losses due to interruption and insurance expenses for all businesses and employees within Jersey City.
- Coordinate between the proposed flood protection infrastructure and landscape projects and the ongoing and foreseen development projects in the city.

### Cost-Benefit Criteria

To determine the value of adaptation implementation, we measure costs, both fiscal and otherwise, against any potential benefits. GIS data is used to determine the assessed value of flood areas, which will be measured against the determined amount of linear feet per adaptation improvement in each Priority Area.

A color-coded matrix has been created for each of the Priority Areas regarding the previously recommended adaptation measures to address the impact of many factors, including socio-economic, historic, transportation, and anticipated disruption. An assessment of how the regulatory environment and ownership issues – public vs. private access, for example - affects the placement of measures also follows.

Each matrix is color-coded, ranking how the proposed adaptation measure will impact a specific factor as follows:

1. Green: Not anticipated to have an adverse effect.

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2. Yellow: Uncertainty requires a caution indicator.
3. Red: Anticipated to have an adverse effect.

The following section includes a detailed assessment of the considerations for each Priority Area and how the adaptation measures reviewed stand under a cost-benefit analysis, using both tangible and intangible factors.

### **Area A, Watershed District 6 (Country Village) - Street Levee**

Located on the east side of Route 440, Area A is generally bounded by the Bayonne municipal boundary to the south, Newark Bay to the west, Society Hill to the north, and Kennedy Boulevard to the east (see Figure 3). For statistical references, we reviewed American Community Survey Five-Year Estimates 2010-2014 for Census Tracts 59 and 61 for demographic data.

The CCAPUCF report recommends building a street levee along the east side of Route 440 which would require raising the roadway three to four feet.

Among the vulnerability factors that are considered are the following:

1. One-percent flood zone extending approximately one-quarter mile east of Route 440.
2. Predominant zoning is the R-1 One- and Two-Family District, with 77 percent of dwelling units either one- or two-family residences.
3. Includes block groups that equal or exceed the regional poverty threshold.
4. Combined sewer overflow at Newark Bay
5. Groundwater contamination reported at an industrial site at the west end of Pamrapo Avenue, west of Kennedy Boulevard.
6. An access ramp to Route 440 Northbound from 63<sup>rd</sup> Street in Bayonne serves as a designated evacuation route. Several local streets provide access to and from Route 440.

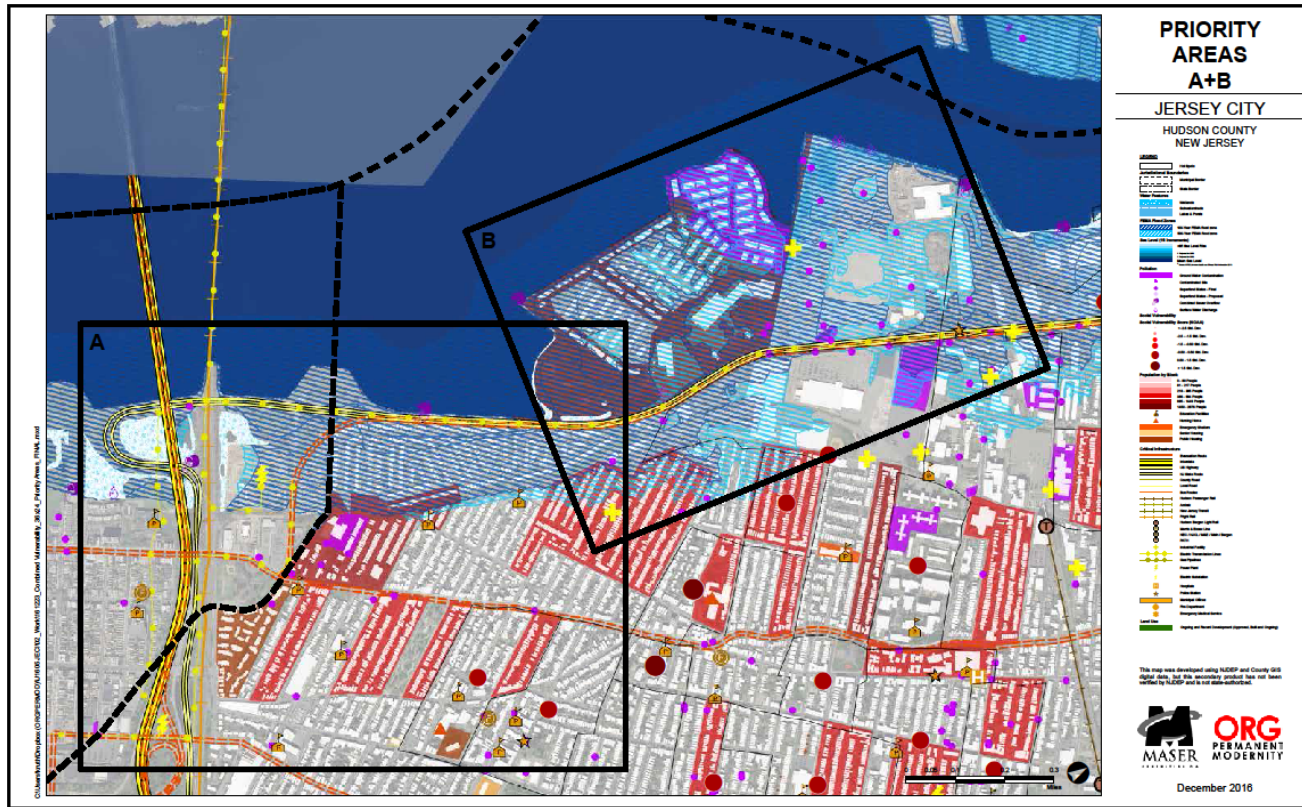


Figure 3: Priority Areas A and B

We assess the implementation of a street levee along Route 440 approximately one-half mile in length on the following table:

**Street Levee – Country Village (Area A)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		The Historic Morris Canal bisects this Area, generally following the path of Route 440. This is not expected to be a problem.
<b>Economic Impact</b>		Construction would have short-term adverse effect on traffic, circulation, and access.
<b>Business Impact</b>		Construction would have short-term adverse effect on traffic, circulation, and access to businesses.
<b>Transportation Infrastructure</b>		In addition to short-term effect or construction, direct access to and from Route 440 from some local would be cut off with the street levee.
<b>Impact on Vulnerable Populations</b>		While access to Route 440 from local streets would be eliminated, there is minimal disruption to the residents.
<b>Technical Feasibility</b>		There is currently a pending Route 440 redesign project, with the City working in collaboration with the State to boulevard the state highway, including complete street redesign, lane reduction, landscaping, etc. The challenge is how to incorporate flood adaptation measures into the proposed boulevard.
<b>Political Feasibility</b>		Requires State and City approval. Local resident concerns about losing direct vehicular access to Route 440.
<b>Administrative Feasibility</b>		NJDOT would be part the administrative process as Route 440 is a State highway. Location near Newark Bay would potentially involve NJDEP.
<b>Environmental Feasibility</b>		No apparent adverse environmental impact is anticipated from this measure, although NJDEP would potentially be involved in review process.
<b>Urban Design Impact</b>		The three to four feet of additional height from a street levee will not adversely impact views of Newark Bay from nearby residents, most of whom have their rear yards facing Route 440 and Newark Bay that have views blocked with existing fences. In addition, the redesign of the road will enhance the aesthetics of the surrounding neighborhood, replacing highway with boulevard.
<b>Implementation Issues</b>		Most land involved in improvements includes State right-of-way. Any additional encroachments would impact residents adjacent to Route 440.



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Costs to construct street levee: Based on approximately 2,000 linear feet to raise the street four feet in height, and approximately 100 feet width at \$30 per linear foot per foot of height, the projected cost of this approach is \$24,000,000

Assessed value of flood prone properties: City tax records indicate the assessed value of flood prone properties located within Resiliency District 6 is \$64,203,100.<sup>9</sup>

Net result: From an intangible standpoint, the potential adverse impacts fall under the potential and/or short-term category. On the positive side, this proposal would have no adverse impact on the historic value of the neighborhood nor would this improvement negatively impact potentially vulnerable populations.



Figure 4: Street levee

As noted in the chart above, a current proposal exists to replace the current Route 440 state highway with a boulevard design. This multi-jurisdictional project between Jersey City and the State of New Jersey would have a positive impact on the overall aesthetic design of the area, and including flood adaptation measures into the boulevard design would provide a functional improvement. However, that project has not yet started. As noted in a May 2011 study presented to the City<sup>10</sup>, total design and construction cost for converting the entire 3.6-mile corridor from highway to boulevard was estimated at \$367 million in 2010 dollars.

We do note caution regarding this proposal given State and City jurisdiction issues since Route 440 is a State highway. Access to and from the Country Village neighborhood via Route 440 would be eliminated. While that would limit potential pass-by traffic from the highway, closing access to Route 440 eliminates direct access for the residents.

<sup>9</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

<sup>10</sup> *Route 440/Routes 1&9T Multi-Use Urban Boulevard and Through Truck Diversion Concept Development Study Abstract and Executive Summary*, prepared for the City of Jersey City and prepared by Jacobs Engineering Group, Inc.; dated May 2011.

In an ideal situation, the street levee should be developed as part of the overall Route 440 Boulevard project. There is certainly interdependence between the proposed street rise and the overall Route 440 Boulevard project, which, if undertaken together, would result in a longer-term project depending on how the street levee proposal would be incorporated into the Route 440 improvements.

Of note, the City completed the *Morris Canal Greenway Plan*, dated May 2013, which proposes a linear park along the historic Morris Canal alignment. While there is potential for raising the proposed pathway along the Canal route to assist as a flood control measure, the pathway area is located east of Route 440 and a large segment of the Country Village residential neighborhood, making it too far east to protect the neighborhood from the adverse effects of flooding.

Generally speaking, the challenges to implementing this recommendation are more short-term, primarily circulation disruption during the construction period. The preferred approach is to raise the highway, whether as part of an overall redesign of Route 440 or as a standalone project specific to this neighborhood.

Creating the street levee brings more certainty to the neighborhood regarding potential flooding events. Local homeowners, many of whom depend on their homes as their greatest investment, will have a greater level of protection for their property in addition to personal safety. When balancing that prospect against what is a minimal adverse impact on aesthetics, the socio-economic outcomes are a net positive for Area A.

**Area B1, Watershed District 6 and 7 (Society Hill) - Boardwalk Levee**

Located on the west side of Route 440, Society Hill is a multi-family residential development that has an existing walkway along its riverfront. (See Figure 3 above.) The CCAPUCF study recommended raising the existing Hackensack RiverWalk five to six feet from its current grade. The walkway distance affected is approximately one mile in length.

Among the vulnerability factors that exist in this area are the following:

1. One-percent flood zone extending approximately one-quarter mile east of Route 440.
2. Combined sewer overflow at Newark Bay
3. Groundwater contamination at the northern portion of Society Hill

The implementation of a boardwalk levee five to six feet above the existing walkway grade for approximately one mile in length is assessed in the following table:

**Boardwalk Levee – Society Hill (Area B1)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		The Historic Morris Canal bisects this Area, generally following the path of Route 440. This is not expected to be a problem.
<b>Economic Impact</b>		No adverse economic impact. i.e. no adverse impact on residential unit values.
<b>Business Impact</b>		No businesses located along walkway.
<b>Transportation Infrastructure</b>		Would involve raising grade of existing walkway.
<b>Impact on Vulnerable Populations</b>		No adverse impact anticipated.
<b>Technical Feasibility</b>		Walkway already exists.
<b>Political Feasibility</b>		Walkway property owned by both the homeowner association and Jersey City; homeowner association involvement and concerns about costs
<b>Administrative Feasibility</b>		Maintenance the responsibility of the homeowner association.
<b>Environmental Feasibility</b>		No adverse environmental impact is anticipated from this measure. NJDEP review anticipated.
<b>Urban Design Impact</b>		The five to six feet of additional grade will have an impact on views of Newark Bay from nearby residences. However, the waterfront walkway views will not be impacted. Potential negative impact on nearby residences is substantially outweighed by improved flood control and continued riverfront walkway access and views.
<b>Implementation Issues</b>		Homeowner association and City approval. NJDEP review likely.

Costs to construct boardwalk levee: Approximately one mile in length (use 5,280 linear feet), raising the walkway six feet high, using a 15-foot wide walkway, at \$20 per linear foot per foot of height, costing an estimated \$9.5 million dollars.

Assessed value of flood prone properties: Among the over 1,400 residential units at Society Hill, the assessed value of those residential properties is \$149,805,500, based on Jersey City tax data.<sup>11</sup>

Net result: The boardwalk levee at Society Hill would be an improvement upon the existing walkway, adding increased flood protection to a one-percent flood zone. Challenges are more administrative and political. The homeowner association owns a portion of the walkway land and is responsible for ongoing maintenance, which is funded through homeowner dues and assessments. From a functional and aesthetic standpoint, this measure has many more positive benefits than not and further development of this plan would be beneficial. Given the limited socio-economic impacts on the area noted in the above chart, the additional safety measures for persons and property result in a net positive for this concern.

Upon reviewing the cost/benefit analysis, the estimated \$9.5 million cost is a small percentage of the assessed value to the more than 1,400 units comprising the Society Hill neighborhood. Even if the cost were double the projection, it still makes sense from a fiscal, long term investment perspective and merits support.



Figure 5: Walkway levee

<sup>11</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

### Area B2, Watershed District 7 (Bayfront) - Land Rise / Street Levee

The CCAPUCF report recommends raising land on the west side of Route 440 as well as Route 440 itself to create a street levee like the one proposed in Area A along Route 440 adjacent to Country Village. (See Figure 3 above.) The improvements would extend approximately one mile in length to the intersection with U.S. Route Truck 1 & 9 and Communipaw Avenue.

Highway commercial uses are prevalent on Route 440, and several redevelopment plans have been approved, including the Bayfront 1 Plan on the west side of Route 440. Bayfront 1 plans for a mixed-use community including residential, commercial, office, and recreation uses.

Interestingly, not discussed in the Baker Report is a potentially less costly alternative to raise the proposed linear park along the historic Morris Canal alignment. Unlike the alignment proximate to Priority Area A, this segment would offer flood protection, with Segments 1 and 2 shown in the *Morris Canal Greenway Plan* generally parallel the eastern side of Route 440, extending from Danforth Avenue to the south, to the Hackensack River to the north, and crossing west over Route 440 at Clendenny Avenue. In fact, the plan recommends that Segment 2 be constructed as part of the redesign of Route 440 as an urban boulevard.<sup>12</sup> Using Off-Street Shared Use Path standards from the *Greenway Plan*, the path is estimated to be 30 feet wide, consisting of 12 to 16 feet of shared use path, a five foot green buffer on one side, and about five to 10 feet for landscaping/amenities.<sup>13</sup> For the entire 5,850 foot length of the proposed walkway, the construction cost is estimated at between \$460,000 and \$646,000. The cost of raising the walkway the entire length is not considered as it was to be integrated into the Route 440 Urban Boulevard Plan.

Among the vulnerability factors that affect adaptation measures in this area are the following:

1. One-percent flood zone on both sides of Route 440.
2. Critical facilities affected include the Municipal Utilities Authority.
3. Several combined sewer overflows at Newark Bay
4. Ground water contamination reported at an industrial site at the west end of Pamrapo Avenue, west of Kennedy Boulevard.

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<sup>12</sup> Morris County Greenway Plan, RBA Group, May 2013, p. A-57

<sup>13</sup> Morris County Greenway Plan, RBA Group, May 2013, p. 62

We assess the implementation of a street levee along Route 440 approximately 1.5 miles in length on the following table:

**Bayfront (Area B2)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		The Historic Morris Canal bisects this Area, generally following the path of Route 440. This is not expected to be a problem.
<b>Economic Impact</b>		During construction, raising Route 440 would have adverse effect on traffic over a significant period given the length of street levee proposed. Construction would have to be in phases.
<b>Business Impact</b>		Potential access and visibility/site identification issues for highway commercial businesses from creation of street levee.
<b>Transportation Infrastructure</b>		Raising highway would create access issues, especially to highway commercial businesses.
<b>Impact on Vulnerable Populations</b>		Significant short- and long-term disruption to the surrounding residents and other property owners.
<b>Technical Feasibility</b>		Many contaminated sites along and on the west side of Route 440. In addition to removing contamination, additional fill above and beyond what is being cleaned is necessary for land rise.
<b>Political Feasibility</b>		Multiple private property owners affected. State DOT has jurisdiction over Route 440.
<b>Administrative Feasibility</b>		Both City and State jurisdiction.
<b>Environmental Feasibility</b>		Bayfront 1 has site contamination from historic industrial uses. Combined sewer overflows and surface water discharge need to be addressed.
<b>Urban Design Impact</b>		Potential need for redesigned access to and from Route 440 properties.
<b>Implementation Issues</b>		State DOT approval for Route 440 improvements, which go beyond street levees alone. Contaminated site cleanup.

Costs to construct street levee: Based on approximately 8,000 linear feet to raise the street four feet in height and approximately 100 feet in width at \$30 per linear foot per foot of height, the projected cost of this approach is \$96,000,000

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With the alternative to raise only the proposed 5,850 square foot Greenway along Route 440 four feet in height and approximately 30 feet in width at \$30 per linear foot per foot of height, the projected cost of this approach is \$5,000,000. The total cost estimate, including improvements to the walkway is \$5,500,000.

Assessed value of flood prone properties: The flood prone properties east of Route 440 located in Area B have an assessed value of \$65,421,400.<sup>14</sup> Flood prone properties west of Route 440 in Area B located north of Society Hill that comprise the Bayfront I Redevelopment Area have an assessed value of \$25,490,800.<sup>15</sup> Obviously the \$25,000,000 figure does not consider future development at this location.

Net result: This ambitious proposal creates multiple short- and long-term issues that are challenging. The highway commercial businesses on Route 440 may have access issues if the street levee were implemented, causing a need to reconfigure the roadway and potentially require eminent domain to acquire land for this purpose. Business visibility would be reduced as well.

As for the land rise, many contaminated sites in the area require clean up even before there is consideration to raising the existing grade. Moreover, the proposed four feet in height may not be sufficient to pull the road safely out of a floodable area. It is imperative that this roadway remain passable during flood events, as it is an evacuation route.

We also note that the proposal to redesign the Route 440 highway into an urban boulevard as noted in the chart above would have a positive impact on the overall aesthetic design of the area. That project has not yet started. Given the size and scale of the roadway redesign, this is more of a long-term project that should be part of the larger undertaking, especially given the potential for interruption and at least short-term displacement. If this project is to be pursued, it should be phased in over a longer period to prevent major disruptions throughout the entirety of Route 440. From a long-term standpoint, there are benefits to this project from an aesthetic and flood protection standpoint. This has to be viewed as a long term project for it to be implemented.

If the Route 440 Urban Boulevard is developed, the Morris Canal Greenway Walkway could be integrated into the plan for a less challenging approach. However, if the prospect of the walkway being constructed sooner than the Urban Boulevard is more likely, this walkway should be designed to provide the flood protection outlined in this section. Using the walkway as a smaller barrier/levee is preferred based on cost.

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<sup>14</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

<sup>15</sup> Ibid.



### Area C, Watershed Districts 7 & 8 (Riverbend) - Street Levee

Centered around US Route 1 & 9 (Tonnelle Avenue), NJ Route 139, and US Truck Route 1 & 9, this area has a convergence of uses, including industrial, highway commercial, and residential uses. The CCAPUCF report recommends building a street levee in this area.

Among the vulnerability factors that affect adaptation measures in this area are the following:

1. One-percent flood zone west of Tonnelle Avenue and Truck Route 1 & 9.
2. Area includes block groups that equal or exceed the regional poverty threshold.
3. Marion Gardens housing project, operated by the Jersey City Housing Authority, is in this area.
4. Critical facilities affected include railroad lines, electric and gas pipelines, and the PSE&G Hudson Power Station, which will be closed in 2017.
5. Several combined sewer overflows at Hackensack River or its tributaries.
6. Multiple contaminated sites.

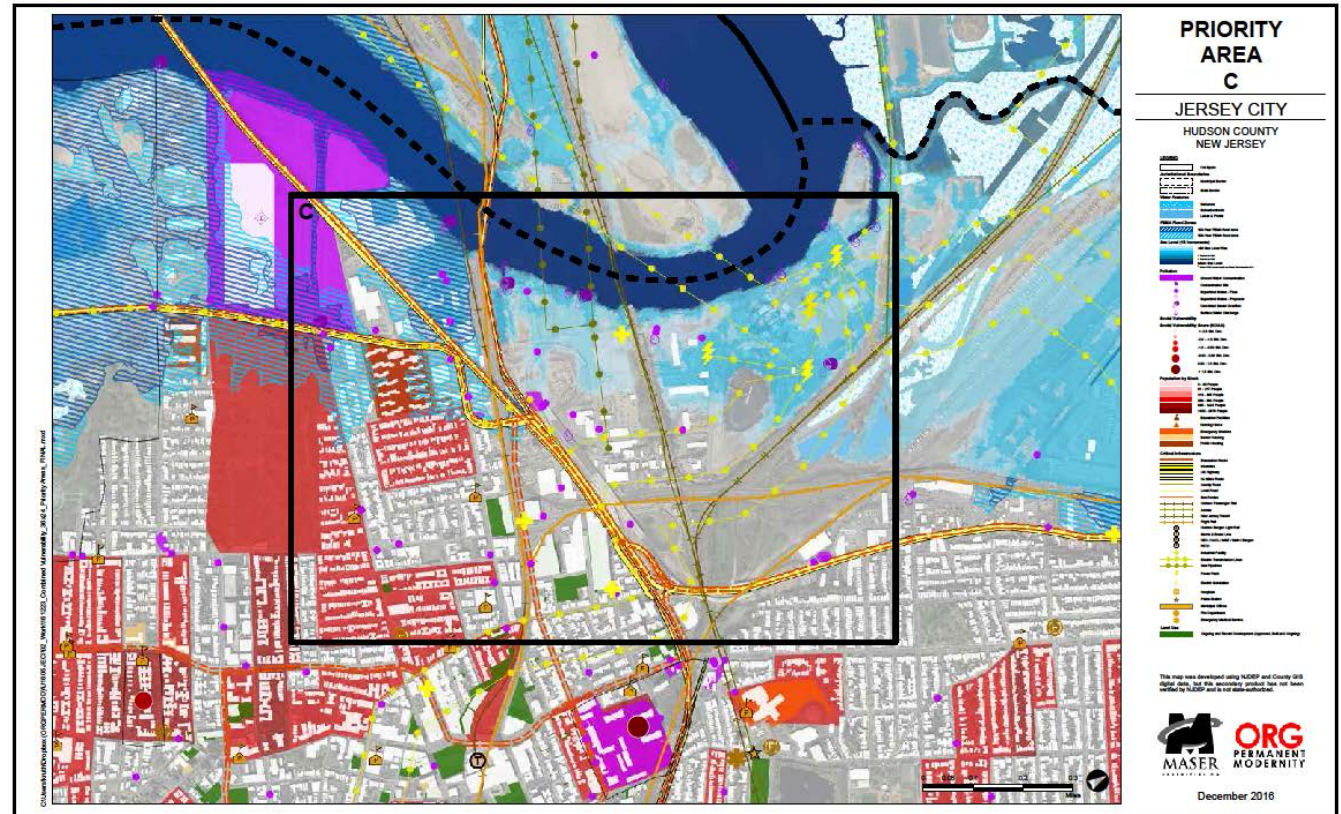


Figure 6: Priority Area C

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An event affecting this analysis is the announcement by PSE&G that it has announced it will be closing its Jersey City coal power plant located in Area C in 2017. Future use of the PSE&G facility has not yet been determined as of this date.

The implementation of a street levee five to six feet above the existing walkway grade for approximately one mile in length is assessed in the following table:

**Riverbend (Area C)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		There are no historic value impact considerations affected by this adaptation measure.
<b>Economic Impact</b>		Construction of raising Tonnelle Avenue would have short-term adverse effect on traffic over a significant period given length of street levee proposed.
<b>Business Impact</b>		Access, visibility issues for highway commercial businesses from creation of street levee. Potential need to acquire properties through eminent domain.
<b>Transportation Infrastructure</b>		Raising highway would create access issues, especially to highway commercial businesses.
<b>Impact on Vulnerable Populations</b>		Potential impact of adaptation measures on Marion Gardens housing project and surrounding neighborhood.
<b>Technical Feasibility</b>		Raising a four-lane roadway presents short- and long-term challenges.
<b>Political Feasibility</b>		Multiple private property owners affected. State DOT has jurisdiction over US Route 1 & 9.
<b>Administrative Feasibility</b>		Both City and State jurisdiction.
<b>Environmental Feasibility</b>		Combined sewer overflows need to be addressed.
<b>Urban Design Impact</b>		Redevelopment plans not directly impacted from proposed adaptation measure.
<b>Implementation Issues</b>		State DOT approval for US Route 1 & 9 improvements, which go beyond street levees alone.

Costs to construct street levee: Based on approximately 5,280 linear feet to raise the street six feet in height, an approximately 70 feet width at \$30 per linear foot per foot of height, the projected cost of this approach is \$65,000,000, not including any potential land acquisition costs.

Assessed value of flood prone properties: The assessed value of the flood prone properties is \$24,004,600.<sup>16</sup>

Net result: The closing of the PSE&G power station in 2017 and the future use of the site has the potential to eliminate a key critical facility in Area C. The question stands how the proposed adaptation measure would serve to protect the railroad facilities. It does not appear it would in any fashion. The street levee would provide greater protection to the Marion Gardens housing project and surrounding neighborhood at a great cost, as noted above. Moreover, this approach would need to be incorporated into any improvements along roadways such as Route 1 & 9 as well as other infrastructure concerns. Less disruptive and cost-efficient measures, such as smaller scale flood walls and other adaptation measures focusing on protecting smaller areas could be developed and operated independently. These smaller measures are appropriate for consideration, as they would offer flood protection to the vulnerable populations in the neighborhood including Marion Gardens, but at a lower cost at with fewer interdependence issues.

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<sup>16</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

**Area D, Watershed Districts 1, 2, & 3 (Mill Creek, Bergen-Lafayette, western Downtown) - Land Rise**

This proposed adaptation measure focuses on raising existing elevations in land around Mill Creek, focusing largely on the Grand Jersey Redevelopment Area. Of note, Area D also includes the Morris Canal Redevelopment Area and extends north to include the western extents of Van Vorst Park and Hamilton Park Historic Districts and the Jersey Avenue Park and Jersey Avenue Tenth Street Redevelopment Plans near the northern boundary of Downtown. The previously proposed measures, however, dealt primarily with the Grand Jersey area. The land around Mill Creek has an elevation as low as three feet NAVD88.

West of Grand Jersey is the Communipaw neighborhood (also referred to as Morris Canal), which in addition to being part of a one-percent flood zone includes vulnerable populations with public housing projects and senior housing.

The Grand Jersey Redevelopment Plan Area incorporates Jersey City Medical Center and the PSE&G Substation at its north end. In addition, the western portion of Downtown is included, specifically the area between the New Jersey Turnpike Newark Bay Extension to the west and Areas E and F to the east.

Among the vulnerability factors that affect the proposed adaptation measure in this area are the following:

1. One-percent flood zone throughout Area D.
2. Historic districts and structures in Area D.
3. Area D includes block groups that equal or exceed the regional poverty threshold.
4. Booker T. Washington housing project, operated by the Jersey City Housing Authority, is in this area. Lafayette Village is also within Area D.
5. Critical facilities affected include Jersey City Medical Center and the PSE&G Substation.
6. All the properties within the Grand Jersey area are brownfields, as defined under New Jersey state law (N.J.S.A. 58:10B-23.d) due to their historic industrial use.
7. Combined sewer overflow at Mill Creek.

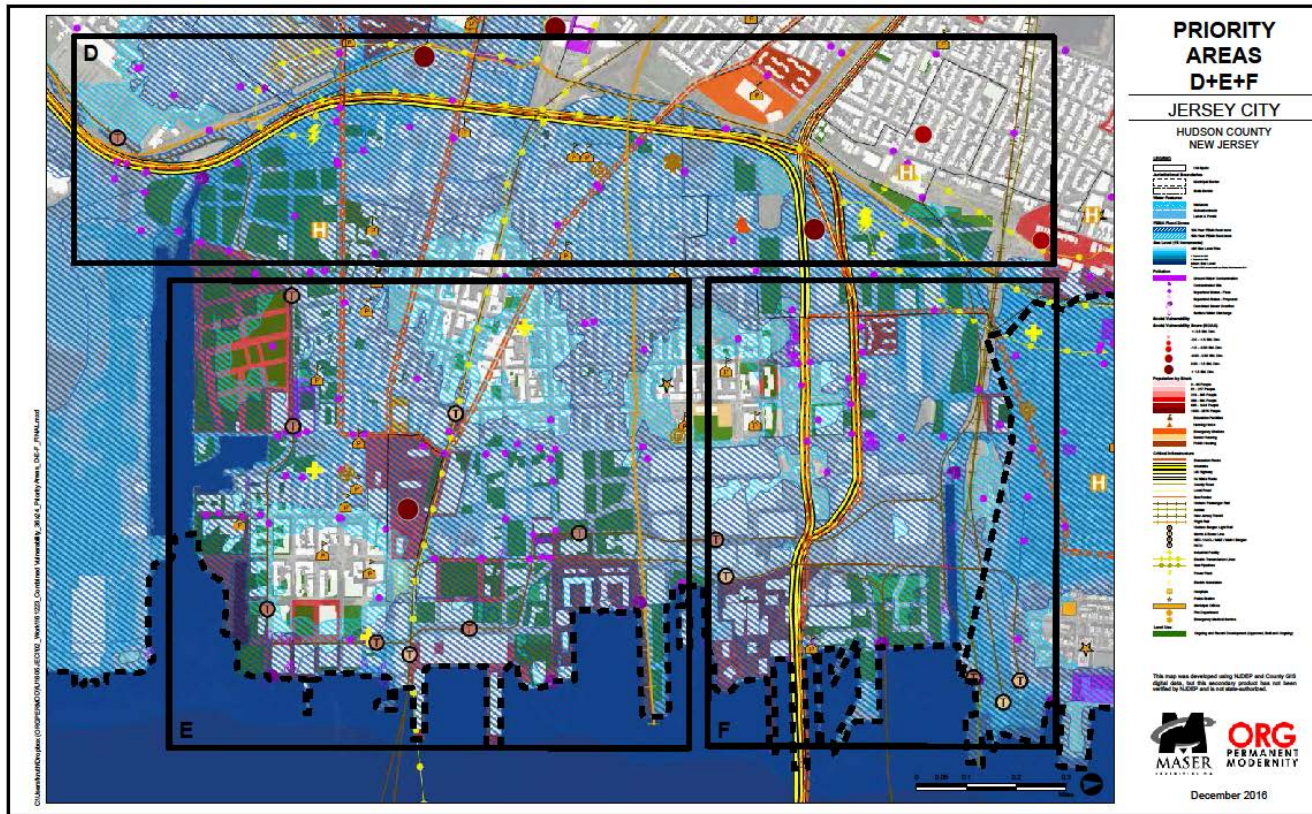


Figure 7: Priority Areas D, E, and F

There is one property within the area that is on the National Register of Historic Places – Whitlock Cordage. Whitlock Cordage is a 7-acre former industrial complex with buildings constructed between 1852 and 1920<sup>17</sup>. The site was used for the manufacture of “the world’s strongest rope.”<sup>18,19</sup>

<sup>17</sup> Karnoutsos, Carmela. "Whitlock Cordage/Whitlock Mills," Jersey City Past and Present, Accessed Oct. 21, 2016. [http://www.njcu.edu/programs/jchistory/Pages/W\\_Pages/Whitlock\\_Cordage.htm](http://www.njcu.edu/programs/jchistory/Pages/W_Pages/Whitlock_Cordage.htm)

<sup>18</sup> Jersey City Landmarks Conservancy, <http://www.jclandmarks.org/campaign-whitlock.shtml>, Accessed Oct. 21, 2106.

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This site should not be negatively impacted. The implementation of land rise of up to 11 feet above current grade in some areas is assessed in the table below:

**Mill Creek (Area D)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		Whitlock Cordage, a former rope mill, is a designated historic site. The Historic Morris Canal bisects this Area, generally along Grand Street.
<b>Economic Impact</b>		The proposed land rise would have a positive impact on the redevelopment area value. However, cost considerations of raising land up to 11 feet a concern.
<b>Business Impact</b>		Raising site for future development would be a net positive for the Redevelopment Area and surrounding neighborhood.
<b>Transportation Infrastructure</b>		Consideration of how land rise may affect street grid and light rail right-of-way.
<b>Impact on Vulnerable Populations</b>		Communipaw neighborhood to west of Grand Jersey area, including several public housing projects. Many block groups exceed regional poverty threshold. Land rise may divert flooding to these neighborhoods. Many community organizations present in the area and will be actively involved regarding any neighborhood adaptation recommendations.
<b>Technical Feasibility</b>		Several contaminated sites in the area.
<b>Political Feasibility</b>		Addressing potential adverse impact from land rise on Communipaw neighborhood to west. Historic district and neighborhood group involvement.
<b>Administrative Feasibility</b>		Site developer may bear costs of this adaptation measure in Grand Jersey Redevelopment Area.
<b>Environmental Feasibility</b>		Combined sewer overflow needs to be addressed. Site contamination a major issue in land rise.
<b>Urban Design Impact</b>		How would land rise affect medical and utility uses, which are only portions of Grand Jersey Redevelopment Area currently developed.

<sup>19</sup> Martinmay, Antoinette. "Commercial Property/Jersey City; A Significant Industrial Site Is Saved for Housing," New York Times, May 11, 2003. [http://www.nytimes.com/2003/05/11/realestate/commercial-property-jersey-city-significant-industrial-site-saved-for-housing.html?\\_r=0](http://www.nytimes.com/2003/05/11/realestate/commercial-property-jersey-city-significant-industrial-site-saved-for-housing.html?_r=0)

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**Costs:** To raise land elevation of only the Grand Jersey Redevelopment Area portion of Area D an additional eight feet from a base elevation of three feet, the cost per acre would be at least \$10,500,000. This is determined using \$30 per square foot multiplied by area square footage and additional height. The Grand Jersey Redevelopment Area is over 31 acres, as indicated in the Grand Jersey Redevelopment Plan. Therefore the total project cost would be \$325.5 million. This cost does not consider dealing with potential site contamination cleanup and relocation of critical facilities such as power substations if necessary. As noted above, this proposal relies on issues such as contamination cleanup and relocation of critical facilities.

**Assessed value of flood prone properties:** The assessed value of properties located in the one-percent flood zone in Area D is approximately \$150,000,000.<sup>20</sup>

**Net result:** There are many complicating factors making the land rise option difficult to support. While it is conceivable to raise the land in the Mill Creek area, there remain questions as to how the medical and utility portions of the Redevelopment Area may be affected by the proposal. Other areas meriting consideration include the Communipaw neighborhood and the Morris Canal Redevelopment Plan Area to the west, which is situated in a one-percent flood zone with many Census tracts exceeding the regional poverty threshold. Other less costly adaptation methods would be more effective. Among those considerations include implementing wet and dry floodproofing on development, which is outlined later in this plan, and smaller scale adaptation measures such as levees.

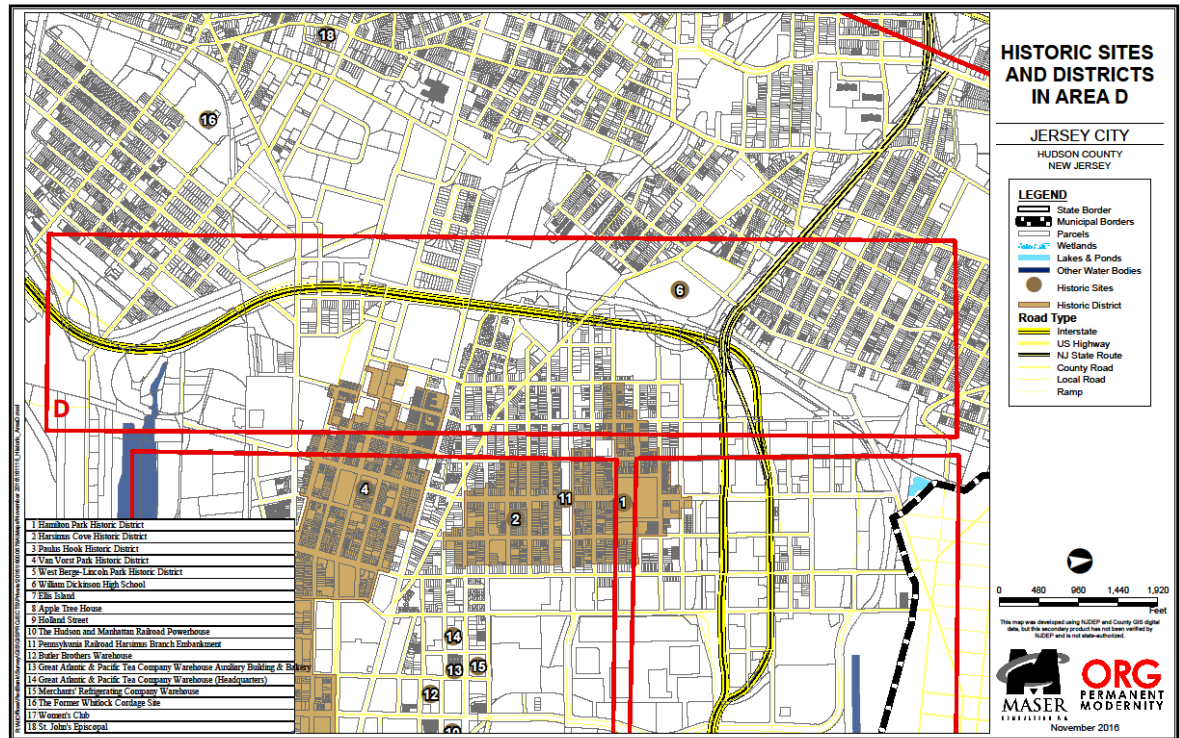


Figure 8: Historic Sites and Districts, Area D

<sup>20</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

## City of Jersey City

These adaptation measures address flooding issues in general and the Communipaw neighborhood specifically, which has a larger vulnerable population that would have a more difficult recovery given their present socio-economic conditions.

### Area E, Watershed District 1 (Downtown South) - Various Adaptation Measures

Initially considered together as Watershed District 1, the Priority Area map designated two Areas – E and F – for Downtown. (See Figure 7.) Area E includes all or parts of historic, long-established neighborhoods such as Paulus Hook, Van Vorst Park, Harsimus Cove, Exchange Place, the Powerhouse Arts District, and Hamilton Park.

Multiple measures were recommended around the Tidewater Basin, including a surge barrier floodgate, a boardwalk levee along the Hudson River Waterfront Walkway, and street levees three feet above the current grade at Dudley Street and Washington Street.

Among the vulnerability factors that affect adaptation measures in this area are the following:

1. One-percent flood zone located in Area E including block groups that equal or exceed the regional poverty threshold.
2. Historic districts prominent in Area E.
3. Critical facilities affected include City Hall, municipal facilities, PATH stations, ferry docks, Hudson-Bergen Light Rail.
4. Contaminated sites and surface water discharge areas.
5. Combined sewer overflow at two locations along Hudson River.

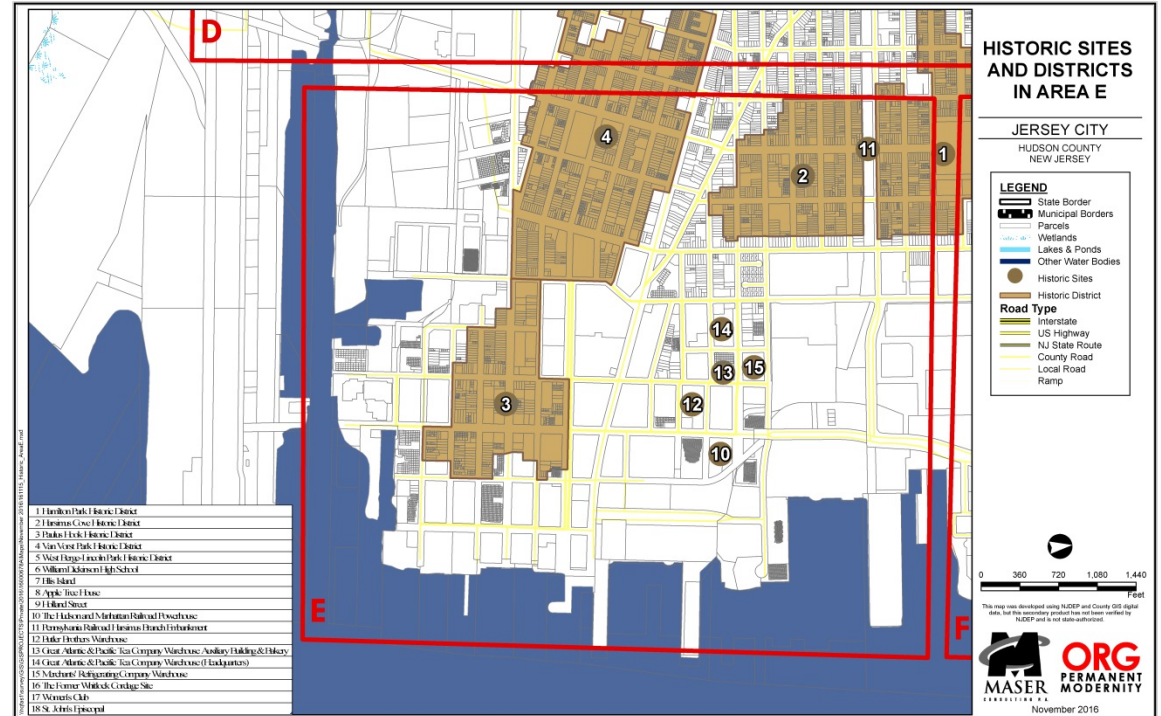


Figure 9 Historic Sites and Districts, Area E



The implementation of the adaptation measures recommended for Area E are assessed in the table below:

**Downtown South (Area E)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		Street levees may block views and adversely impact existing streetscape. Surge barrier floodgate may adversely impact views from neighborhood. The Historic Morris Canal runs through this Area.
<b>Economic Impact</b>		While street levee is intended to reduce economic losses, concerns about impact of improvements on existing businesses, especially small businesses.
<b>Business Impact</b>		Potential access, visibility issues for commercial businesses from creation of street levee.
<b>Transportation Infrastructure</b>		Street levee would create access concerns both short-term during construction and longer term. Impact on light-rail line.
<b>Impact on Vulnerable Populations</b>		One-percent flood zone in western portion of Area E includes groups that equal or exceed regional poverty threshold.
<b>Technical Feasibility</b>		Surge barrier floodgate most complex of adaptation measures.
<b>Political Feasibility</b>		Multiple private property owners affected. Historic district and neighborhood group involvement. City, State and potential Federal (US Army Corps) approvals.
<b>Administrative Feasibility</b>		Both City and State jurisdiction.
<b>Environmental Feasibility</b>		Combined sewer overflows and surface water discharge impacts need to be addressed.
<b>Urban Design Impact</b>		Street levees would block views and adversely impact existing streetscape. Surge barrier floodgate impact views from neighborhood.
<b>Implementation Issues</b>		City, State, and Federal jurisdiction.

Costs to construct recommended storm surge barrier: A storm surge barrier generally presents high construction costs. One example is the Harvey Canal Flood Protection Barrier near New Orleans, LA, constructed by the US Army Corps of Engineers in 2008. This barrier has two sector gates

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which enclose a 125-foot-wide channel that is 16 feet deep and the gates protect to an elevation of 11.5 feet. This project took three years to complete at a cost of over \$1 billion dollars.

Costs to construct street levee: Based on approximately 1,000 linear feet of roadway, the projected cost to raise the street four feet in height with approximately 60 feet in width at \$30 per cubic foot is \$7,200,000.



Figure 10: Street levee

Assessed value of flood prone properties, with specific focus on historic districts in Area E: The Paulus Hook Historic District, which includes portions of York, Grand, Sussex, Essex, Greene, Washington, Warren, and Van Vorst Streets was originally included on the State Register of Historic Places in 1981 and the National Register of Historic Places in 1982. This district was expanded to include portions of York, Henderson, and Van Vorst Streets in 1985, and again recognized on the State and National Registers. Among Jersey City Historic Districts, Paulus Hook is located closest to the Hudson River although it is located at a higher elevation than surrounding neighborhoods. Comprising all or portions of 13 blocks, the assessed value of properties in the district is \$96.6 million dollars.<sup>21</sup>

Van Vorst Historic District includes portions of Jersey Avenue, and Varick, Barrow, Grove, Wayne, Mercer, Montgomery, York, Bright, and Grand Streets. The district was designated on the State Register in 1978 and the National Register in 1980. This neighborhood is located west of Paulus Hook and is vulnerable to flooding and sea level rise. As noted in City tax records, the assessed value of 15 city blocks located entirely within the district boundaries is approximately \$161 million dollars.<sup>22</sup>

Harsimus Cove Historic District comprises portions of Jersey Avenue, and Bay, Coles, Erie, First, Second, Third, Fourth, and Fifth Streets, and Grove Street/Manila Avenue. The district was designated in the State and National Registers in 1987. Based on review of City tax records, the

<sup>21</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

<sup>22</sup> Ibid

assessed value of 15 tax map blocks located mostly or entirely within the district boundaries is approximately \$87 million dollars.<sup>23</sup>

Hamilton Park comprises all or parts of 19 blocks, generally located on Sixth, Seventh, Eighth, Ninth, Tenth, Erie, Coles, Monmouth and Brunswick Streets, and Jersey and Pavonia Avenues, centered around Hamilton Park. The district was designated in the State Register in 1978 and the National Register in 1979. Based on our review of City tax records, the assessed value of the 19 tax map blocks located entirely or partially within the district boundaries is approximately \$152,000,000.<sup>24</sup>

The total assessed value of the four historic districts is approximately \$500 million dollars. This measure does not consider other Downtown area parcels, both residential and non-residential. In addition, building content values should also be considered. Common practice is to apply a ratio of the structure value to content value, with 30 percent used generally.

Net impact of Street Levee. From an intangible standpoint, this proposal would have a significant adverse impact on the historic districts and the existing streetscape. There would be short-term impacts due to construction and potential dislocation. A street levee would also lead to long-term changes in terms of access and aesthetics. However, given the projected cost relative to the assessed value of properties being protected, it should be considered as part of an overall comprehensive plan to address flood control and sea rise.

Net impact of Storm Surge Barrier. The most complex measure proposed is the surge barrier gate at the Tidewater Basin. In the visualization plan presented by Baker, a horizontally moving or rotating gate was chosen. This storm surge barrier would have a length of approximately 300 feet across the Tidewater Basin. Among the advantages are that ferries and other boats would not be impacted by the measure under normal circumstances. The gate would be a fixed barrier immediately ready for operation.

Issues that would need to be resolved with a storm surge barrier are many, including who or what entity would be responsible for construction and maintenance, and under what circumstances would it be used. In addition to the gates, a large space and deep excavation would be required to house the gates. Ongoing maintenance to avoid a silt buildup as well as barrier maintenance would incur significant costs.

Cost of constructing this type of storm surge barrier would be high. Based on the Harvey Canal Flood Protection Barrier near New Orleans, LA discussed above, it would take several years to complete and a potential cost of over one billion dollars. Given the long term nature of such a project and the complexity of development, construction of this type of storm surge barrier is interdependent on many factors, such as dredging as noted in

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<sup>23</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

<sup>24</sup> Ibid.

the prior paragraph, consensus on an ongoing maintenance plan, etc. This is certainly not a short-term project. However, given the assessed value of the historic districts, downtown commercial areas, and the potential positive flood control impacts, this type of storm surge barrier should be considered for a long-term project to address flood control issues.

Net impact of Boardwalk Levee. A boardwalk levee would be an improvement upon the existing walkway, adding improved flood protection to a one-percent flood zone. Challenges are more administrative and political. Specifically, the entities responsible for ongoing maintenance must be determined. From a functional and aesthetic standpoint, there is concern about the proposed height, up to 14 feet above mean sea level. This measure has many more positive benefits than not.

Net impact of Earthen Berm. This measure would be the least disruptive in terms of development, as it would be located on State parkland, and can be developed independently of other adaptation projects. The major challenge is having the State approve of and fund the improvement on their land, as well as to get the buy-in of the Friends of Liberty State Park community organization.

**Area F, Watershed District 1 (Downtown North) - Various Adaptation Measures**

The other section of Resiliency District 1, Area F includes the northern portion of Downtown, including Newport and the Holland Tunnel access. (See Figure 7.) A key difference between Area F and Area E is that most of Area F has only limited historic district properties or long established neighborhoods except for a northern portion of the Hamilton Park Historic District. The changing neighborhood and new development is highlighted by the number of redevelopment plans that have been adopted in this area, the most prominent being the Newport Redevelopment Plan which covers the eastern portion of Area F and the Jersey Avenue Redevelopment Plans to the north and west.

An approximately one-mile long street levee along Washington Street is suggested by the CCAPUCF study, also raising the intersection of Washington and Morgan Streets six to seven feet above current grade was previously recommended. Among the vulnerability factors that affect adaptation measures in this area are the following:

1. One-percent flood zone located in Area F including block groups that equal or exceed the regional poverty threshold.
2. Critical facilities affected include the Holland Tunnel, PATH stations, ferry docks, Hudson-Bergen Light Rail, as noted above
3. Contaminated sites and surface water discharge areas.
4. Combined sewer overflow at three locations along Hudson River.

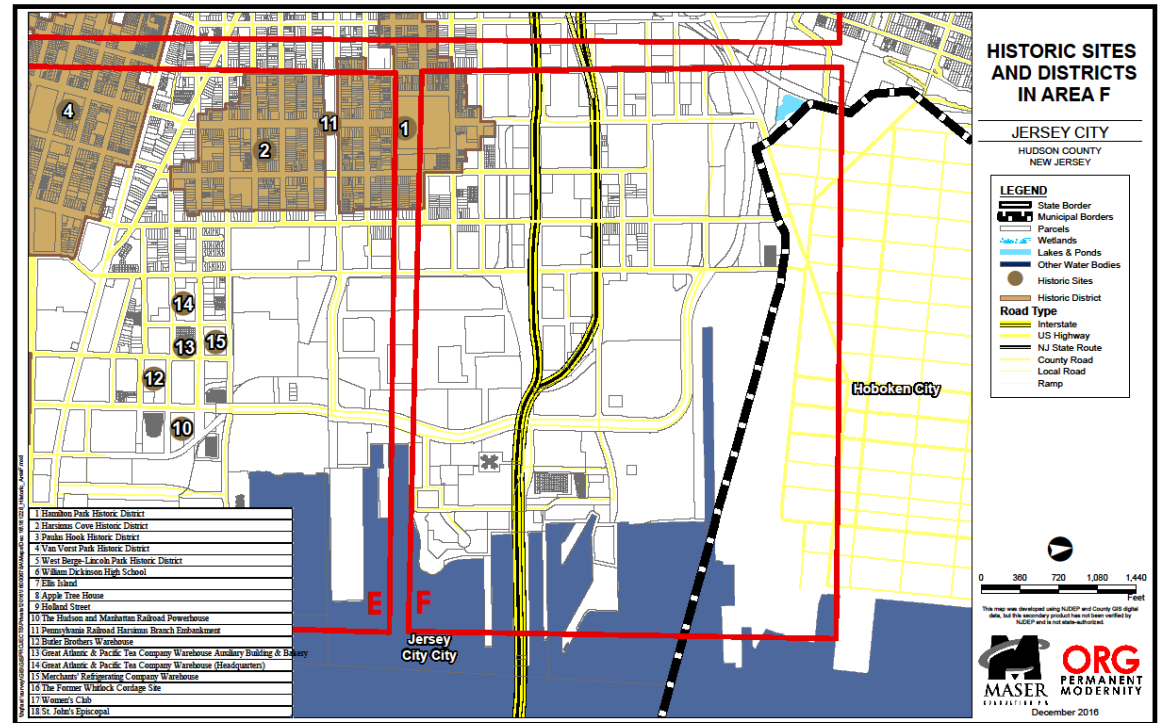


Figure 11: Historic Sites and Districts, Area F

The implementation of the adaptation measures recommended for Area F is assessed in the following table:

**Downtown North (Area F)**

<b>Considerations</b>	<b>Ranking of Adverse Impacts</b>	<b>General Assessment of Adverse Impacts</b>
<b>Historic Value</b>		Concern about impact on Lackawanna Rail Yard.
<b>Economic Impact</b>		While street levee is intended to reduce economic losses, concerns about impact of improvements on existing businesses, especially small businesses.
<b>Business Impact</b>		Potential access, visibility issues for commercial businesses from creation of street levee.
<b>Transportation Infrastructure</b>		Raising roadway would create access issues for existing development. Access to PATH stations and the Hudson-Bergen Light Rail line would be affected by such measures. Area includes several interstate transportation modes and multiple agencies having jurisdiction over transportation measures.
<b>Impact on Vulnerable Populations</b>		Neither measure would necessarily have a direct impact on vulnerable populations.
<b>Technical Feasibility</b>		Raising a four lane roadway presents short- and long-term challenges. Access between the east and west sides of Washington Street would be more challenging.
<b>Political Feasibility</b>		Multiple private property owners affected. City jurisdiction.
<b>Administrative Feasibility</b>		In addition to City jurisdiction, other agencies potentially involved include Port Authority of NY & NJ, New Jersey Transit.
<b>Environmental Feasibility</b>		Combined sewer overflows and surface water discharge and how proposed levee has impact.
<b>Urban Design Impact</b>		Street levees would adversely impact streetscape and access, particularly to PATH trains. Crossing between the east and west sides of Washington Street would be adversely impacted
<b>Implementation Issues</b>		In addition to City jurisdiction, other agencies potentially involved include Port Authority of NY & NJ, New Jersey Transit.

Costs to construct street levee: Based on approximately 5,280 linear feet to raise the street approximately six to seven feet in height, approximately 80 to 100 feet width at \$30 per linear foot per foot of height, the projected cost of this approach is \$100,000,000.

Assessed value of flood prone properties: Assessed value of flood prone properties: Immediately to the west of Washington Street, the four blocks between Christopher Columbus Drive to the south, Warren Street to the west and First Street to the north have an assessed value of approximately \$40 million dollars.<sup>25</sup>

Net impact: From an intangible standpoint, a street levee would have an adverse impact on the existing development along Washington Street, specifically access. Short-term impacts due to construction and potential dislocation improving the street would lead to long-term changes in terms of access and aesthetics. However, given the assessed value of the properties immediately affected, this street levee has significant benefits over time given the cost relative to the assessed value of properties. In addition, such a project would be dependent on other factors such as existing and proposed infrastructure improvements, more specifically the impact on mass transit such as PATH and NJ Transit Light Rail (HBLR).

To address flooding in Area F, a flood protection barrier along the south side of the New Jersey Transit rail yards is recommended. This could be accomplished either by using the rail's right of way and building a wall along its edge, or by building a wall/berm along the northern side of 18th Street. To resolve current road crossings, which are very low in elevation, a combination of regrading and deployables should be part of the solution. Ideally, the area should be regraded two to three feet and then deployables used. (Deployables only will not resolve more frequent high tides and sea level rise induced events.) Such flood protection would extend to the face of the Palisades. Coordinating developing this barrier with neighboring Hoboken would be ideal, although this would be part of a longer-term strategy between the two cities

A smaller scale idea worth consideration is to place wet weather pumping stations at key locations throughout this Area. Such pumping stations would prevent storm water from flooding the sewer lines and coming back up into the streets. More of a stop gap, this option provides a measure that could be implemented in the short term and provide some relief from flooding in vulnerable areas. Other green infrastructure measures such as tree pits and rain gardens could be included in a more comprehensive proposal with these pump stations. Based on costs from North Hudson Regional Sewerage Authority for their Hoboken project, each wet weather pumping station project could cost in the range of \$12 to \$15 million. Depending on demand, multiple stations may be appropriate but should be reduced through other green infrastructure measures.

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<sup>25</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

### **Summary of Feasibility Analysis**

The cost-benefit analysis of prior recommendations reveals that little consideration for the local community needs in each area surrounding the originally recommended adaptation measures. Each neighborhood in Jersey City clearly has its own character and limitations, creating possible barriers to implementation.

The CCAPUCF report, for example, did not take issues such as historic value, impact on populations or businesses, political feasibility, or economic impact into consideration. As shown in the feasibility and cost benefit analyses above, the previously recommended adaptation measures for Areas B2, C, D, and E would have a number of potentially negative impacts or obstacles. Area C, for example, was recommended for a Street Levee in prior studies. However, expected negative impacts on the economic, business, and transportation sectors lead us to instead to opt for less intrusive measures as will be discussed below.

Prior studies also did not consider political vulnerability or municipal budgeting. While some solutions may have high effectiveness, cost in both dollars and political capital can be prohibitive.

To fill this analytical gap, the following section sets forth new Project Recommendations, considering the character of the given area, political constraints, economic impacts to businesses, cost, and other real-world effects of the implementation of any given recommendation as identified in the Cost-Benefit analysis.



## V. Project Recommendations

The above sections have evaluated prior recommendations under a local lens. Adaptation measures have been placed within Priority Areas based on socio-economic and geographic criteria, and the feasibility of the recommendations have been subject to a cost-benefit analysis using both feasibility/impact criteria and the City's Resiliency Goals and Objectives to ensure that the solutions are consistent with the larger vision of the City.

We note the following factors to consider when comparing large-scale infrastructure adaptation measures against the subsidized adaptation of existing and future structures:

1. What are the associated costs, disruptions, and lasting impacts of larger-scale infrastructure solutions such as walls and levees as opposed to subsidizing adaptations of existing ground floors, which focuses on structures rather than whole neighborhoods?
2. How would a public funding option be built into the City ordinance? How would subsidies be determined and provided? The major risk is that requesting public funding for building adaptation measures is an at-will option, i.e., participation is voluntary for existing structures.
3. Imposing adaptation measures on a larger area may not get universal political support. Such measures are almost always more expensive.

Additionally, administrative measures should also be taken to further strengthen Jersey City's resilience, including zoning changes, future planning studies and analyses, and participation in the Community Rating System to become eligible for flood insurance price reductions.

### Physical Adaptation Recommendations

#### *Adaptation Measures for Priority Areas (A-F)*

The adaptation measures recommended for the Priority Areas and their specific location are noted below. Each of the Area recommendations can succeed independently, and is not reliant on the implementation of the others, making implementation possible in phases as needed. The measures recommended are compatible with the Watershed District lines of protection.

**Area A: Street Levee - Country Village.** It is recommended that a street levee be built along the west side of Route 440. This will involve raising the roadway by three to four feet. This will ensure that not only Country Village is protected, but ensures that Route 440 itself remains a safe, dry

evacuation route. The street should be raised for the entirety of Area A, but should continue north to the extent determined necessary by engineers in order to control floodwater inundation.

As it relates to the other recommended adaptation measures, the proposed street levee works independently in its protection of Country Village. That is, water will be diverted from Country Village either south toward Bayonne and Richard A. Rutkowski Park with the benefit of vast pervious area and no development, or north toward Society Hill where there is currently a raised walkway. Although this report does recommend raising the Society Hill walkway levee for maximum protection, diverted water from Area A would not breach it in moderate-case scenarios.

As discussed above, the area is within the one-percent flood zone, is zoned R-1 with an abundance of one- and two-family homes, includes block groups that equal or exceed the regional poverty threshold, there is a combined sewer overflow at Newark Bay, groundwater contamination has been reported at an industrial site, and the Area includes an access ramp to a designated evacuation route. The assessed property value in the area is \$64,203,100.<sup>26</sup> All of these factors make protecting this area a priority.

The projected cost of this approach is \$24,000,000, and any potential adverse impacts fall under the potential and/or short-term category. This street levee could be incorporated into the existing 440 Boulevard State of New Jersey project, or as a standalone project specific to this neighborhood. The total number of residents benefited by this measure would be over 2,000.

See Appendix illustrations for *Coastal Flood Zones – West Jersey City* and *Coastal Flood Protection – West Jersey City* for graphics on the protection available.

**Area B1: Society Hill Boardwalk Levee.** It is recommended that the existing Hackensack RiverWalk be raised five to six feet from its current grade. The walkway distance affected is approximately one mile in length.

The boardwalk levee project will be most successfully undertaken after the recommended street levee at Country Village is complete. If the boardwalk levee were done first, water which would have naturally affected Society Hill may be diverted south to Country Village where the flooding threat is already high, thereby exacerbating the flood impact.

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<sup>26</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

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As discussed above, this area lies within the one-percent flood zone, there is a combined sewer overflow at Newark Bay, and groundwater contamination exists at the northern portion of Society Hill. The assessed value of the residential properties in this area is \$149,805,500, based on Jersey City tax data.<sup>27</sup>

It is expected that the yet-to-be-completed project at Bayfront, just north of Society Hill, will be developed with responsible flood protection measures, including but not limited to raising grade and/or requiring that all habitable space be raised above flood level or wet/dry floodproofed. It is also recommended that the Hackensack RiverWalk extension at Bayfront be raised as recommended herein for additional flood protection and consistency with Society Hill.

The projected cost of this approach is \$9.5 million, and any potential adverse impacts fall under the potential and/or short-term category. This recommendation pairs perfectly with the existing effort to create a continuous Hackensack RiverWalk, and would directly benefit 1,400 households.

See Appendix illustrations for *Coastal Flood Zones – West Jersey City* and *Coastal Flood Protection – West Jersey City* for graphics on the protection available.

**Area B2: Walkway Levee:** While the idea of a street levee Area B2 proves to have significant short- and long-term challenges, a walkway levee along the Morris Canal Greenway is a similar, though less complicated and less costly approach. Because there are very significant needs to protect the commercial businesses in this area as well as pending residential and mixed use development, such as Bayfront, making the walkway levee a recommended project in conjunction with Route 440 Boulevard State project is an ideal solution. The raised walkway has fewer negative effects on future site access and visibility that could result from raising the entire street.

As discussed above, the vulnerability factors affecting this area are that it lies within the one-percent flood zone, critical facilities are located in the area, there are several combined sewer overflows at Newark Bay, and ground water contamination has been reported at an industrial site.

Aside from interdependence between the proposed land rise and the overall Route 440 Boulevard project, the walkway rise recommendation functions independently from the other recommendations in this plan. That is, if this project were to take place prior to the recommendations to the north or south, there would be limited unwanted impact. To the south, Society Hill would be at least moderately protected by the existing boardwalk, and although the area to the north may experience flood inundation, it is unclear that there would be any significant detriments.

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<sup>27</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

The projected cost of this approach is \$5.5 million, and \$90 million of assessed properties will be protected.<sup>28</sup>

**Area C: Small-Scale Flood Walls:** It is recommended that small-scale, site specific flood walls be implemented to protect infrastructure assets in Priority Area C.

Area C is unique, in that its priority is based primarily on infrastructure rather than residents or businesses. This area includes PSE&G facilities, rail yards, and scattered industrial uses. As such, protecting the entire area would not be cost effective. Rather, flood walls can be used to keep water away from specific areas and buildings. These barriers would be composed of flood-damage-resistant materials and appropriate for site-specific protection. Wet and dry floodproofing of buildings is also recommended. Wet floodproofing allows a building to anticipate flooding and not be destroyed by water entering the structure. Dry floodproofing creates a watertight structure with all elements substantially impermeable to the entrance of floodwater and with structural components having the capacity to resist flood loads.

Protecting the assets in this area is estimated to cost of \$65,000,000, most of which could be paid for by property owners wishing to protect their own facilities, significantly lowering the cost to the City as compared to other infrastructure alternatives. For example, PSE&G as well as the rail lines are not the responsibility of Jersey City. The City may need to engage in some educational outreach to the property owners to encourage them to take protective actions.

As discussed earlier in this report, this area includes a one-percent flood zone, block groups that equal or exceed the regional poverty threshold, Marion Gardens housing project, critical facilities (including railroad lines, electric and gas pip), several combined sewer overflows at Hackensack River or its tributaries, and multiple contaminated sites. The assessed value of the flood prone properties is \$24,004,600.<sup>29</sup>

Small-scale flood walls and other adaptation measures focusing on protecting smaller areas can be developed and operated independently of other adaptation measures. Because these methods offer flood protection to smaller, contained areas, floodwaters will generally not be diverted out of the larger Area but will continue to protect the most vulnerable.

**Area D:**

1. **Berms / Levees:** In the short term, it is recommended that targeted levees and berms be implemented in Area D, rather than large-scale land rise like that recommended by the *CCAPUCF* and *Visualizations* reports. During flood events, Area D is significantly impacted by

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<sup>28</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

<sup>29</sup> Ibid.

water entering from the south through the Tidewater Basin and into Mill Creek and from the north through the Long Slip Canal at the Hoboken border. These two flood entry points must be addressed in order to prevent flooding in the back end of town which was historically a marshy area. This area also has vulnerable populations and pockets of poverty which merit special attention.

As discussed earlier in this report, vulnerabilities within this area include the one-percent flood zone, historic districts and structures, block groups that equal or exceed the regional poverty threshold, the Booker T. Washington and Lafayette Village housing projects, Jersey City Medical Center and the PSE&G Substation, brownfields sites, and a combined sewer overflow at Mill Creek. Protection of this area is critical. The assessed value of properties is approximately \$150,000,000.<sup>30</sup>

In the southern end of this area the State is planning to build a bridge connecting Jersey Avenue from Downtown to Liberty State Park. This project is separate and distinct from the adaptation measures recommended in this report. The final design for the bridge unfortunately does not raise Jersey Avenue above the 100-year flood elevation. In the same area, approved project plans for the “Crescent Park” project raise Jersey Avenue approximately 5 to 6 feet above existing grade between the Hudson-Bergen Light Rail tracks and the bridge, fill part of the Mill Creek, and raise the Crescent Park development area by approximately 6 to 9 feet above existing grades. However, Jersey Avenue and Johnston Avenue will remain possible pathways for floodwaters to enter downtown Jersey City and the Morris Canal Redevelopment Area and beyond.

Unfortunately, the presence of the Hudson-Bergen Light Rail tracks and the already-finalized plans for the future Jersey Avenue bridge make it impossible to raise Jersey Avenue to the ideal eight feet above existing grade. Alternatively, raising the entire Grand Jersey Redevelopment Area out of the flood zone is prohibitively expensive.

To protect the area in the short term, it is recommended that in coordination with the land and street rise proposed with the Crescent Park project, additional berms be strategically located at vulnerable points just north of Jersey Avenue to compensate for any residual flooding that is not deterred by the raised street.

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<sup>30</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

Along the northern end of Area D, adjacent to Hoboken, the Long Slip Canal is expected to be filled above flood elevation as part of a NJ Transit rail yard expansion project. As with the Jersey Avenue bridge project, this is separate and distinct from the adaptation measures recommended in this report, though coordination is critical. Additionally, adaptation measures recommended for Area F (that is, deployables and wet weather pumping stations) should also benefit the northern end of Area D. To the extent that water still inundates the area, small, targeted levees should be able to resolve any residual flooding.

The total cost of this undertaking, as discussed above, would be \$150 million (substantially less than the earlier studies' suggestion for land rise at a cost of \$325.5 million), and it would result in the protection of historic structures, public housing communities, the PSE&G substation, and the Jersey City Medical Center. The social value of these critical facilities, vulnerable populations, and cultural assets are well worth protecting. To raise land elevation an additional eight feet from a base elevation of three feet, the cost per acre would be at least \$10,500,000. This cost does not consider dealing with potential site contamination cleanup and relocation of critical facilities such as power substations if necessary. As noted above, this proposal relies on issues such as contamination cleanup and relocation of critical facilities.

## **2. Extensive Engineering Study**

Because of the aforementioned limitations to raising Jersey Avenue the desired eight feet above existing grade (that is, the Jersey Avenue bridge project and the existing Hudson-Bergen Light Rail tracks), gaps remain in the land barriers where water will be able to infiltrate the area. The small berms and levees discussed above will address this problem, but are more of a “band aid” than a long-term cure.

The existing infrastructure and critical facilities, including the New Jersey Turnpike, HBLR, Jersey City Medical Center, and CSO make protection of this area critical, but at the same time their locations and existing conditions limit the adaptation measures which are feasible in the area.

It is recommended that a comprehensive engineering study be undertaken to address Area D, including the CSO (which has already been studied to some extent in the *Mill Creek Initial Design + Finance Analysis and Recommendations* prepared by Build it Green) as well as the threat of storm surge. The complexity of this area merits special attention in order to develop a long-term, cost-effective solution that will thoroughly protect all of the residents, businesses, and infrastructure located therein.

**Area E:** As discussed earlier in this report, Area E includes a one-percent flood zone, block groups that equal or exceed the regional poverty threshold, historic districts, contaminated sites and surface water discharge areas, two combined sewer overflows, and critical facilities (including City Hall, municipal facilities, PATH stations, ferry docks, and the Hudson-Bergen Light Rail). The total assessed value of the four historic districts is approximately \$500 million dollars<sup>31</sup>, which does not include other Downtown area parcels, both residential and non-residential, or building content values.

There are two recommended measures to be taken in Area E.

1. **Dudley/Washington Street Levee.** It is recommended that Dudley and Washington Streets be raised three to four feet above grade. This effort should have no impact on the historic character or eastern views that the area is so well known for. At an estimated cost of \$7.2 million, it is also one of the most affordable physical adaptation recommendations in this report. Because the location is directly on the Hudson River waterfront, the benefits should be immediately apparent upon construction.

This recommendation can stand independent from other adaptation measures, though the amount of property protected is relatively small. Preventing water from breaching the banks at Dudley and Washington will protect portions of Paulus Hook by diverting waters to the two adjacent parks or retaining it within the Hudson River. However, properties to the north, including Exchange Place, will see no benefit.

2. **Hudson River Waterfront Boardwalk Levee.** It is recommended that the Hudson River Waterfront Walkway in Area E be converted into a Boardwalk levee with a height of up to 14 feet above mean sea level. Because the Hudson River Waterfront Walkway is already in place, modifications to it may be acceptable to the public. The Waterfront Walkway would sit atop the levee, and additional space for outdoor recreation should be encouraged as space allows. The cost of this undertaking would be \$4 million, though the number of residents and businesses immediately adjacent to the waterfront that would benefit from this adaptation measure is tremendous, with over \$500 million in assessed value of historic neighborhoods alone.

The boardwalk levee in Area E is contingent on the street levee (also in Area E) being completed first. While the street levee is a significantly smaller project, without this first being completed the water which would have naturally flooded the boardwalk levee area will be pushed south to Dudley and Washington Streets where it will easily penetrate inland. If, however, the street levee is finished first, the

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<sup>31</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.

water from the entirety of Area E will be forced south to Liberty State Park, where ample pervious land without development can accept floodwaters.

See Appendix illustrations for *Coastal Flood Zones – Downtown*, *Coastal Flood Protection – Downtown*, and *Coastal Flood Protection – Hudson Waterfront* for graphics on the protection available.

**Area F:** Area F includes a one-percent flood zone, block groups that equal or exceed the regional poverty threshold, critical facilities including the Holland Tunnel, PATH stations, ferry docks, Hudson-Bergen Light Rail, contaminated sites and surface water discharge areas, and three combined sewer overflows. The area has an assessed value of approximately \$40 million dollars.<sup>32</sup>

There are two recommended measures to be taken in Area F.

1. **Rail Yard Flood Protection Barrier.** It is recommended that a flood protection barrier be developed along the south side of the NJ Transit rail yards. This could be done either by using the rail's right of way and building a wall along its edge, or by building a wall/berm along the northern side of 18th Street which would extend to the face of the Palisades. To resolve current road crossings, which are very low in elevation, a combination of regrading and deployables should be part of the solution. Ideally, the area should be regraded two to three feet and then deployables used. (Using only deployables will not resolve more frequent high tides and sea level rise induced events.)

Coordination of this project with neighboring Hoboken and NJ Transit would be necessary, and ideally part of a longer-term inter-agency strategy. This recommendation, however, can stand independent from other adaptation measures

Under typical circumstances, deployables are used sparingly to minimize manpower required to implement such measures in a relatively short time frame. However, in this location street levees are not recommended because they can be problematic from a cost and design standpoint. A street levee would have an adverse impact on the existing development along Washington Street, specifically access. Short-term impacts such as dislocation during construction and potential long-term changes in terms of access and aesthetics are likely. Nevertheless, given the assessed value of the properties immediately affected, protection is critical, and deployables would offer fewer negative impacts. Additionally, deployable flood barriers can be adjusted based on the length, shape, and height of the area needing flood defense.

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<sup>32</sup> Jersey City tax records, Hudson County Board of Taxation website, accessed 2016.



Protecting this area affects not only the new neighborhood currently growing, but access to and from the Holland Tunnel as well as Hoboken. The projected cost of this approach varies depending on the type of deployable barrier, starting at approximately \$30.00 per linear foot for a three-foot high “wall”. Higher barrier heights increase the price per linear foot. The minimum cost of this could be as low as \$110,000, and with higher or more substantial walls the price could go as high as \$1.1 million. The assessed value in the immediate area is \$40 million. Because this is a temporary measure, deployed only on an as-needed basis, there is no permanent aesthetic concern or neighborhood impact. There is, however, a labor cost with each deployment. However such cost, even if it were double the estimated cost of the deployables, is more cost efficient than the street levee. Moreover, this project works well in cooperation with the filling of the Long Slip Canal.

2. **Wet Weather Pumping Stations**: A smaller approach is to place wet weather pumping stations at key locations throughout this Area.

When the combined sewer system reaches capacity during heavy rainfall, water can be treated at a wet weather treatment facility before it is discharged to local water bodies. This method helps protect human health and the environment by reducing the amount of untreated combined sewage that overflows into the Hudson River by preventing storm water from flooding the sewer lines and coming back up into the streets.

More of a stop gap, this option provides a measure that could be implemented in the short term and provide some relief from flooding in vulnerable areas. Other green infrastructure measures such as tree pits and rain gardens could be included in a more comprehensive proposal with these pump stations. Based on costs from North Hudson Regional Sewerage Authority for their Hoboken project, a wet weather pumping station project could cost in the range of \$12 to \$15 million.

This recommendation can stand independent from other adaptation measures, though is not intended as a permanent solution. And, though low in cost, it should be noted that this solution should be expected to handle severe rainfall but impact will be limited against tidal flooding.

An order of priority for recommendations is deployables, then wet weather pumping stations.

The considerable flood protection improvements, based on the implementation of protection surrounding all eight identified watersheds, is depicted in the Appendix, *Coastal Flood Protection – Overview*, *Coastal Flood Protection – Downtown*, and *Coastal Flood Protection – West Jersey City*. These images illustrate the current flood inundation extents as well as the future conditions if and when the line of protection around the perimeter of Jersey City is implemented.

### *Ongoing Maintenance Adaptation Measures*

In addition to adaptation measures appropriate to specific Priority Areas, there are several options which would be better described as “ongoing maintenance” measures that apply citywide. In other words, short-term actions that build on efforts that have been engaged by the City and other agencies to address flooding and other vulnerability concerns. These types of adaptation measures, although fairly new to the City, are increasingly being implemented by other communities. These measures may be publically or privately implemented.

To reduce flooding risks associated with increased precipitation, the following measures are recommended:

1. Downspout Disconnection. Reduce flooding, and pressure on combined sewer systems. Potentially reduces number of treatment plant overflows and improves storm water quality. Currently, many downspouts in Jersey City connect directly from roofs to the sewer system, rather than discharging onto the property. During heavy rainfall connected downspouts add to an already overloaded sewer system, increasing the risk of basement flooding and releasing polluted rainwater into local waterways. Disconnecting downspouts helps reduce the amount of stormwater sent through the sewer system. Less stormwater can help prevent wastewater from backing up and thus reduce your risk of basement flooding. This measure is anticipated as a private undertaking.
2. Mandatory Backwater Valves. Reduce the risk of basement flooding to individual homes. Specifically, backwater valves protect from contaminated sewer water backing-up into homes and businesses. These valves are used in drainage pipes where reversal of flow causes the valve to close and cut off the flow. It is also known as a Back Flow Valve, and is often used to prevent sewage from flowing back into the home. This is anticipated as a private undertaking.
3. Enhance Sewer Maintenance & Camera Inspection of Sewers. Reduce the risk of basement flooding. Allows prioritization of sewer repairs/replacement and identifies problems before the required repairs become very costly and disruptive to residents and businesses. This is anticipated as a public undertaking, and is in addition to and enhanced by the City’s street sweeping program which currently prevents over 1,800 tons of debris from entering the storm sewers.<sup>33</sup>
4. Green Infrastructure. Capture, delay, and discharge stormwater. Green infrastructure measures, both large and small, are recommended citywide based on soils and topography. These opportunities are discussed in depth in Jersey City 2017 Urban Environmental Green Infrastructure Master Plan. This is anticipated as both a private and public undertaking.

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<sup>33</sup> Source: Jersey City MUA, A. Kahn email May 24, 2017.

5. Other measures that would reduce the risk of basement flooding and the volume of combined sewer overflows include consideration of additional off-line storage for stormwater, increasing the use of flow restrictors on catch basins, and sealing manhole covers, where possible and practical. Generally, this is anticipated as a public undertaking, though in some cases may be tied to approvals for large private development.

### **Construction Adaptation Measures**

In addition to the adaptation methods discussed above, adaptations to the ground floors of existing structures or adaptive design of future construction located in a flood area should be considered. Public funding is often available for these measures, which are referred to as wet flood proofing and dry flood proofing.

To Reduce Risks Associated with flooding, the following measures are recommended:

1. Wet flood proofing includes permanent or contingent measures applied to a structure or its contents that prevent or provide resistance to damage from flooding while allowing floodwaters to enter the structure or area. Generally, this includes properly anchoring the structure, using flood resistant materials below the Base Flood Elevation (BFE), protection of mechanical and utility equipment, and the use of openings or breakaway walls.

Application of wet flood proofing as a flood protection technique under the National Flood Insurance Program (NFIP) is limited to enclosures below elevated residential and non-residential structures and to accessory and agricultural structures that have been issued variances by the community. This is anticipated as a private undertaking.

2. Dry flood proofing includes any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents.

The NFIP allows a new or substantially improved non-residential building in an A Zone (Zone A, AE, A1-30, AR, AO or AH) to have a lowest floor below the BFE, provided the design and methods of construction have been certified by a registered professional engineer or architect as being dry flood proofed in accordance with established criteria.

Flood proofing of areas below the BFE (base flood elevation) in residential buildings is not permitted under the NFIP except in communities that have been granted an exception to permit flood proofed basements. Flood proofing is not permitted in Coastal High Hazard Areas (Zone

V, VE, or V1-30). It is recommended that flood proofing be implemented up to one foot above BFE for a factor of safety and to receive full credit for flood insurance rating.

Limited enclosed areas below grade within newly constructed and substantially improved residential and non-residential structures may be permitted provide that they are wet flood proofing. Certain other categories of structures may be allowed to be wet flood proofed if a variance is issued and other requirements are met. This is anticipated as a public undertaking.

### **Administrative Adaptation Measures**

It should be noted that of the projects listed below, many if not all can be completed in-house. The Adaptation Action Plan Matrix at the end of this document estimates the cost of doing each with the assumption that the work may be done by an outside company. Should the City find it within its capacity to perform the studies in-house, the costs could be significantly lower.

### ***Zoning Changes***

As part of the larger resiliency measures being undertaken by Jersey City, new zoning requirements pertaining to all aspects of property development are currently under consideration and pending adoption. Changes to permitted uses, particularly on the lower floor(s) in flood zones, are under consideration. Building height, design considerations for buildings without active street frontages, securing hazard materials in flood-prone areas, and stormwater reduction/retention methods will be discussed.

Additionally, it is recommended that the city institute a green building/green infrastructure requirement for parcels located in V and AE FEMA flood zones. This approach has been undertaken in other cities around the world, and it assigns a point value to various stormwater mitigation and green infrastructure elements of a project. A required number of points in any given zone must be achieved in order to have a compliant development, allowing the City to target areas that are particularly susceptible to flooding or which have the potential to significantly reduce stormwater runoff, ensuring that resiliency measures are part of all new development. Should the implementation of this approach be successful, it could easily be broadened to other areas of the City.

Although the adoption of changes will be in the immediate short term, this will likely be an ongoing effort. As engineers, landscape architects, and designers come up with new ways to handle the challenges of sea level rise and flooding, so too should Jersey City stay on the cutting edge of good design. As more effective solutions are realized, the City's zoning can be modified accordingly.

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Additionally, should the City determine that entire properties may be better used as open space for the absorption of stormwater or other green solutions, zoning can be revised to permit parks and open space in new zones, thus facilitating acquisition of land for such uses.

### ***Infrastructure Bank***

It is recommended that Jersey City explore the possibility of charging impact fees to developers based on a given project's effect on the stormwater system. NJSA 40:55D-42 allows municipalities to impose such a fee when a direct connection can be demonstrated between the project and the incurred expense.

The City should conduct a legal and administrative analysis on this approach, as such fees could be useful tools for creating an "infrastructure bank" to fund the adaptation projects recommended herein.

### ***Community Rating System***

The City and flood insurance policy holders would benefit from participation in the NFIP Community Rating System (CRS), a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. In the 2014 Hudson County Hazard Mitigation Plan Update, it was noted that Jersey City has considered joining CRS in the past although a coordinator had not been named.

Participation in CRS would result in discounted flood insurance premium rates reflective of the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

1. Reduce flood losses;
2. Facilitate accurate insurance ratings; and
3. Promote the awareness of flood insurance.

Through CRS participation, Jersey City will be better able to evaluate its flood program's effectiveness against nationally recognized benchmarks. Technical assistance in designing and implementing some activities is available at no charge. The premium reduction is another added incentive to continue maintaining its flood programs over the long term.

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The Return on Investment (ROI) from implementing the aforementioned actions creates an enhanced floodplain management program which benefits the City as a whole, and reduced FIRM premiums for Jersey City policy holders. The benefits of some of the other CRS activities (e.g., the public outreach, hazard mitigation planning and projects implemented under CRS) could help protect residents and business owner lives and property during severe weather events. Improved protection of property and reduced strain on emergency services is anticipated to yield additional financial benefits to the City, its residents and business owners. From both a tangible and intangible standpoint, the ROI for Jersey City's involvement in the program is positive over the long term.

### *Jersey City Master Plan Update*

The City's Master Plan, adopted in 2000 and amended multiple times since, includes 10 elements in addition to its goals and objectives. It is essential that each of the Plan elements be updated to reference adaptation and resiliency planning.

1. Land Use Plan. Incorporate the findings and recommendations of the Adaptation Plan into future land use decisions. Future Land Use Map amendments, or a separate Risk Map, should incorporate data from the Adaptation Plan, inclusive of one-percent flood zones and other at risk areas.
2. Urban Design Plan. Include reference to building codes that require resilient design, and add an additional goal promoting adaptive building and reuse.
3. Housing Element and Fair Share Plan. As with the urban design element, such resilient design policies should be incorporated in a wide range of housing types throughout the City.
4. Circulation Plan. Acknowledge in the Circulation Plan the impact of flooding and potential sea level rise on the City's circulation network.
5. Utility Service Plan. Include reference to how critical infrastructure, electric, gas, water, sewer, and other services are impacted by the Adaptation Plan findings.
6. Community Facilities Plan. The Adaptation Plan findings will impact community facilities, including City owned buildings and other properties, parks and recreation facilities, schools, etc., and need to be referenced.
7. Recreation and Open Space Plan. Identify recreation and open space resources most vulnerable to flooding and sea level rise.

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8. Historic Preservation Plan. Include recommendations to encourage structures becoming more resilient while protecting the City’s historic resources.
9. Relationship to Other Planning Efforts. Set as a goal to cooperate and work with neighboring municipalities, to the most practical extent possible, to address adaptation and resiliency measures to mitigate regional risks regarding flooding and other natural hazards.

***Hazard Mitigation Plan***

Hazard mitigation is defined by FEMA as “sustained action taken to reduce or eliminate long-term risk to life and property,” and involves planning, policy change, programs, projects, and other activities that can mitigate the impacts of hazards on a community or defined area. Mitigation strategies rely on many bodies of influence, including businesses, local, state, and federal government, and property owners.

While Jersey City was studied in the 2015 Hudson County Hazard Mitigation Plan (HMP), it is recommended that the City pursue funding for a local Hazard Mitigation Plan, which will provide more in-depth analysis, recommendations, and action planning for all City-specific hazards. Moreover, although the City would already benefit from the County’s Hazard Mitigation Plan with regard to CRS participation, a local Plan should increase the City’s leverage to receive funding for identified capital improvement projects. Hazard Mitigation Plans should be updated every five years to ensure that they remain current.

***Floodplain Management/Flood Mitigation Plan***

FEMA defines Floodplain Management as the operation of a community program of preventive and corrective measures to reduce the risk of current and future flooding, resulting in a more resilient community. High standards for floodplain management will create safer, stronger, and more resilient communities.

Approximately 40 percent of the City’s land area is within the one-percent annual chance floodplain area. With that in mind, it is recommended that the City pursue funding for a Floodplain Management Plan.

Though a 2008 Stormwater Management Plan was adopted, a Floodplain Management Plan could take that a step further to include sea level rise, major storm events, and the concept of a “living shoreline” or other waterfront solutions.

### ***Repetitive Loss Area Analysis***

A Repetitive Loss Area Analysis (RLAA) is typically completed in conjunction with the Floodplain Management Plan and Hazard Mitigation Plan described above. An RLAA should, both in text and through mapping, identify local properties that sustain repetitive losses (thereby putting stress on the National Flood Insurance Program), and can make recommendations as to how to address and manage such properties to reduce risk. The preparation of the RLAA can also provide additional points for the City's CRS program.

### ***Critical Facilities Analysis***

Critical facilities — including power sources, data centers, communications centers, command and control centers, emergency response sites, and public safety and law enforcement facilities — need to be identified and mapped so that they can be properly protected. A second tier of facilities, including schools and libraries, should also be considered. Such a database will ensure that these facilities are protected and are sufficiently robust to remain in operation during emergencies.

### ***Citywide Public Health Adaptation Measures***

While the initial focus in most cases is on the physical environment when it comes to flooding risk, it is necessary to address public health concerns among the recommended adaptation measures. We offer the following recommendations:

1. Develop and implement preparedness and response plans for each at-risk group regarding public health. Where such measures are in place and have not been recently reviewed, update to reflect current concerns.
2. Establish ongoing education programs regarding the health-related aspects of flood risk and the adverse impacts. Items requiring emphasis include preparedness and communicating with health care providers, decision makers, at-risk populations, and the public at large.
3. If already implemented, continue ongoing education of City staff regarding hazard mitigation, especially addressing environmental and health concerns.

### ***Off-Street Parking Initiative***

It is recommended that Jersey City implement an off-street parking initiative for use during emergencies. By recruiting existing parking garages to participate in such a program, vehicles which typically park on the street or in below-grade garages could temporarily park in such facilities for free or at low cost. This would be useful not only during time when floodwaters threaten subsurface garages, but during times where snow removal or



other citywide emergencies are in effect. Examples of garages that would be ideal candidates include Newport Mall, various facilities at Exchange Place, and those around Grove Street.

## VI. Financing Adaptation

There are numerous funding sources and initiatives that Jersey City can participate in in order to increase its resiliency and undertake the recommendations outlined above. The following is a list of funding sources that can assist in creating a more resilient Jersey City.

### Community Rating System (CRS)

It is recommended that Jersey City become a Community Rating System (CRS) eligible community. Property owners in communities under the CRS which implement floodplain management actions that go beyond the minimum requirements of the National Flood Insurance Program (NFIP) are eligible for discounts of between 5 and 45 percent on flood insurance premiums for properties within that community.<sup>34</sup>

The CRS scores and classifies towns on their effectiveness in dealing with the mitigation of flood hazard events, based on three goals:

1. Reduce flood damage to insurable property;
2. Strengthen and support the insurance aspects of the NFIP; and
3. Encourage a comprehensive approach to floodplain management.<sup>35</sup>

### New Jersey Environmental Infrastructure Trust (NJEIT)

NJEIT is an independent State financing authority that provides low-interest rate loans (“H2IOans”) to qualified borrowers in New Jersey for water quality and infrastructure projects.

“Clean Water” loans are available for Wastewater Projects associated with sewage collection, treatment or disposal, including correction of inflow/infiltration problems, sludge management and combined sewer overflows. Loans are also available for Stormwater Projects including

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<sup>34</sup> FEMA, *National Flood Insurance Program Community Rating System: A Local Official’s Guide to Saving Lives; Preventing Property Damage; Reducing the Cost of Flood Insurance*, 2015.

<sup>35</sup> Tetra Tech, *State of New Jersey 2014 Hazard Mitigation Plan*, Sec. 5.

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construction, expansion or replacement of stormwater management systems, construction or expansion of basins, replacement of storm drains and rehabilitation of tide gates and extension of outfall points.<sup>36</sup>

Green projects which Jersey City may wish to implement to reduce the impact of rainwater are also eligible, including replacing existing pavement with porous pavement, utilizing bioretention, constructing green roofs, creating rain gardens, and other practices that mimic natural hydrology and increase effective perviousness.<sup>37</sup>

At the time of this report, the Jersey City Municipal Utilities Authority, in partnership with Rutgers University, was pursuing these funds for several green infrastructure projects.

### **Flood Mitigation Assistance (FMA) Program**

The FMA program seeks to reduce or eliminate claims under the National Flood Insurance Program (NFIP). FMA provides funding to local communities for projects and planning that reduces or eliminates long-term risk of flood damage to structures insured under the NFIP. FMA funding is also available for management costs.<sup>38</sup>

Funding for FMA is very limited and applications must come from local governments or other eligible organizations. The federal cost share for an FMA project is 75 percent. At least 25 percent of the total eligible costs must be provided by a non-Federal source. At minimum, a FEMA-approved local flood mitigation plan is required before a project can be approved.<sup>39</sup>

### **Pre-Disaster Mitigation (PDM) Program**

The PDM Program is designed to assist local communities in implementing a sustained pre-disaster natural hazard mitigation program, with the goal of reducing overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in future disasters. This program awards planning and project grants and provides opportunities for raising public awareness about reducing future losses

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<sup>36</sup> New Jersey Environmental Infrastructure Trust, Clean Water (CWRSF) website: <https://www.njeit.org/cwsrf>, Accessed July 26, 2016.

<sup>37</sup> New Jersey Environmental Infrastructure Trust, Clean Water (CWRSF) website: <https://www.njeit.org/cwsrf>, Accessed July 26, 2016.

<sup>38</sup> FEMA, Flood Mitigation Assistance Grant homepage: <https://www.fema.gov/flood-mitigation-assistance-grant-program>, Accessed July 26, 2016.

<sup>39</sup> Tetra Tech, [\*Hudson County Hazard Mitigation Plan\*](#), 2015 Update, Section 6.4.4.

before disaster strikes. Mitigation planning is a key process used to break the cycle of disaster damage, reconstruction, and repeated damage. PDM grants are funded annually by Congressional appropriations and are awarded on a nationally competitive basis.<sup>40</sup>

FEMA requires the adoption of a hazard mitigation plan as a condition for receiving funding for PDM mitigation projects.

### Emergency Management Performance Grant (EMPG)

The Emergency Management Performance Grant Program plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. The EMPG supports efforts to build and sustain core capabilities across the five mission areas of Prevention, Protection, Mitigation, Response, and Recovery based on allowable costs.<sup>41</sup>

### Homeland Security Grant Program (HSGP)

Like the EMPG above, HSGP plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. The HSGP supports efforts to build and sustain core capabilities across the five mission areas of Prevention, Protection, Mitigation, Response, and Recovery based on allowable costs.<sup>42</sup>

HSGP is comprised of three interconnected grant programs including the State Homeland Security Program (SHSP), Urban Areas Security Initiative (UASI), and the Operation Stonegarden (OPSG). Together, these grant programs fund a range of preparedness activities, including planning, organization, equipment purchase, training, exercises, and management and administration.<sup>43</sup>

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<sup>40</sup> FEMA, Pre-Disaster Mitigation Grant Program homepage: <http://www.fema.gov/pre-disaster-mitigation-grant-program>, Accessed July 26, 2016.

<sup>41</sup> FEMA, Emergency Management Performance Grant homepage: <https://www.fema.gov/fiscal-year-2016-emergency-management-performance-grant-program>, Accessed July 26, 2016.

<sup>42</sup> FEMA, Fiscal Year 2016 Homeland Security Grant Program homepage: <https://www.fema.gov/fiscal-year-2016-homeland-security-grant-program>, Accessed July 26, 2016.

<sup>43</sup> FEMA, Fiscal Year 2016 Homeland Security Grant Program homepage: <https://www.fema.gov/fiscal-year-2016-homeland-security-grant-program>, Accessed July 26, 2016.

### **Community Development Block Grants (CDBG)**

Entitlement Community grants through CDBG are federal funds, through the Department of Housing and Urban Development (HUD), intended to provide low and moderate-income households with viable communities, including decent housing, as suitable living environments, and expanded economic opportunities. Eligible activities include community facilities and improvements, roads and infrastructure, housing rehabilitation and preservation, development activities, public services, economic development, planning, and administration. Public improvements may include flood and drainage improvements.<sup>44,45</sup>

### **NJDEP Blue Acres Floodplain Program**

Properties and structures that have been damaged by, or may be prone to incurring damage caused by, storms or storm-related flooding, or that may buffer or protect other lands from such damage, are eligible for acquisition through the DEP Blue Acres Program. All Blue Acres acquisitions must be from willing sellers.<sup>46</sup>

### **NJDEP Green Acres Program**

Green Acres provides low interest loans and grants to assist local governments in the acquisition and development of open space for recreation and conservation purposes. Should Jersey City wish to acquire property for open space to increase pervious coverage and mitigate the impact of rainfall, these funds would be applicable.<sup>47</sup>

### **NOAA Coastal Resilience Grants**

NOAA Coastal Resilience Grants funds projects that build resilience, including activities that protect life and property, safeguard people and infrastructure, strengthen the economy, or conserve and restore coastal and marine resources. One of the eligible grant categories is for the strengthening of coastal communities through activities that improve capacity of multiple coastal jurisdictions to prepare and plan for, absorb impacts of, recover from, and/or adapt to extreme weather events and climate-related hazards, and typical award amounts range from \$250,000 to \$1 million

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<sup>44</sup> Tetra Tech, *Hudson County Hazard Mitigation Plan*, 2015 Update, Section 6.4.4.

<sup>45</sup> The Department of Housing and Urban Development HUD Exchange, Community Development Block Grant Entitlement Program website: <https://www.hudexchange.info/programs/cdbg-entitlement/>, Accessed July 26, 2016.

<sup>46</sup> New Jersey Department of Environmental Protection (NJDEP), Blue Acres Floodplain acquisition website: [http://www.nj.gov/dep/greenacres/blue\\_flood\\_ac.html](http://www.nj.gov/dep/greenacres/blue_flood_ac.html), Accessed July 26, 2016.

<sup>47</sup> New Jersey Department of Environmental Protection (NJDEP), Green Acres Program website: <http://www.nj.gov/dep/greenacres/>, Accessed July 26, 2016.

for projects lasting up to three years with cost-sharing through cash or in-kind contributions expected. While the NOAA one deadline is March 15, 2017, it should be noted that additional rounds of funding are likely.<sup>48</sup>

### NJ Department of Health Healthcare Preparedness Program

New Jersey's Department of Health Healthcare Preparedness Program's purpose is to enhance emergency preparedness across the healthcare continuum in NJ through coalitions. Eligible grant applicants include hospitals, non-profits, local health departments, federally qualified health centers, and regional health preparedness coalition members.<sup>49</sup>

### Resilience Bonds

Resilience bonds are a variation on conventional Catastrophe Bonds that link insurance and resilience projects to monetize avoided losses such as a reduction of flood insurance claims. The benefits offered for risk-reduction projects which work as preventative measures, such as flood barriers, are monetized up-front and captured through a rebate structure. The resulting rebate serves as a source of predictable funding which communities can proactively invest in projects that strategically reduce risk, like storm surge protections in the Mill Creek project.

## VII. Action Plan Matrix

As discussed earlier in this document, the Implementation Action Plan seeks to guide the implementation of this Plan's recommendations based on six strategies: preparedness, public safety, crucial infrastructure, resilient redevelopment, stormwater management, and property acquisition. Those strategies are now combined into a matrix along with a timeline, parties responsible for oversight, and cost. Each recommendation is categorized into one or more of the six strategies in order to ensure that all needs of the city are being met and no recommendations are outside the efforts of this Plan.

<sup>48</sup> National Oceanic and Atmospheric Administration (NOAA), NOAA 2017 Coastal Resilience Grants website: <https://www.coast.noaa.gov/resilience-grant/>, Accessed February 24, 2107.

<sup>49</sup> State of NJ Department of Health, Directory of Grant Programs website: <https://healthapps.state.nj.us/noticeofgrant/noticegrants.aspx>, Accessed February 24, 2107.

Jersey City Adaptation Action Plan													
Priority Level	Recovery Project	Lead Contact	Involved Departments and Divisions	Cost Estimate	Estimated time to Implement	Possible Funding Sources	Strategies Addressed						
							Preparedness	Public Safety	Critical Infrastructure	Resilient Redevelop.	Stormwater Mgt.	Property Acquisition	
High	1.	Citywide ongoing maintenance	Construction Code Official, property owners	JCMUA; Office of the Constr. Code Official; Div. of Engineering; Div. of Architecture	private costs	ongoing, immediate start	NJEIT (for green implementation), CDBG	x	x	x			
	2.	Zoning changes	Dir., Div. of City Planning	Div. of City Planning; Div. of Zoning Enforcement; Engineering	\$30,000	1-2 y ears	(for green implementation) NJEIT, CDBG, PDM, NJDEP-Blue, NJDEP-Green	x	x	x	x	x	x
	3.	Construction Adaptation	Construction Code Official	Office of Constr. Code Official; Div. of Zoning Enforcement	private costs	ongoing, immediate start	NJEIT, FMA, CDBG, NOAA	x	x		x		
	4.	Engineering Study of Mill Creek/Grand Jersey	Dir., Div. of City Planning	Div. of City Planning; Div. of Zoning Enforcement; Engineering	\$100,000+	1-2 y ears	EMPG	x	x	x		x	x
	5.	Street Levee (Area A)	Engineering	Engineering; OEM	\$24,000,000	1-2 years	FMA		x	x		x	
	6.	Berms & Levees (Area D)	Engineering	Engineering; OEM	\$150,000,000	1-2 y ears	NJEIT, FMA		x	x		x	

Jersey City Adaptation Action Plan													
Priority Level	Recovery Project	Lead Contact	Involved Departments and Divisions	Cost Estimate	Estimated time to Implement	Possible Funding Sources	Strategies Addressed						
							Preparedness	Public Safety	Critical Infrastructure	Resilient Redevelop.	Stormwater Mgt.	Property Acquisition	
Medium	1.	Boardwalk Levee (Area E)	Engineering	Engineering; OEM	\$4,000,000	8+ years	FMA		x	x	x		
	2.	Floodplain Management/Flood Mitigation Plan	Dir., Div. of City Planning	Div. of Planning; Div. of Engineering	\$80,000	3-7 years	EMPG, FMA	x	x			x	x
	3.	Critical Facilities Analysis	Dir., OEM	OEM; Div. of Engineering	\$280,000	1-2 years	EMPG	x	x	x		x	
	4.	Off-Street Emergency Parking Initiative	Division of Parking	Division of Parking	No cost to implement, cost of agreement TBD	1-2 y years	PDM, EMPG	x	x				
	5.	Boardwalk Levee (Area B1)	Engineering	Engineering; OEM	\$9,500,000	8+ years	FMA		x	x	x		
	6.	Street Levee (Area E)	Engineering	Engineering; OEM	\$7,200,000	3-7 years	FMA		x	x		x	
	7.	Repetitive Loss Area Analysis	Dir., Div. of Engineering	Div. of Engineering, Div. of Planning	\$75,000	3-7 years	EMPG		x	x	x		x
	8.	Update Master Plans, etc.	Dir., Div. of City Planning	Div. of City Planning	\$125,000	3-7 years	EMPG	x		x	x	x	x
	9.	Flood Protection Barrier (Area F)	Engineering	Engineering; OEM	varies substantially, \$110,000 - \$1.1m	3-7 years	FMA		x			x	
	10.	Flood Walls (Area C)	Engineering	Engineering; OEM	primarily private cost	3-7 years	FMA		x	x		x	
	11.	Wet Weather Pumping Stations (Area F)	JCMUA	Engineering; OEM	15000000	3-7 years	NJEIT, FMA, CDBG	x	x			x	

Jersey City Adaptation Action Plan													
Priority Level	Recovery Project	Lead Contact	Involved Departments and Divisions	Cost Estimate	Estimated time to Implement	Possible Funding Sources	Strategies Addressed						
							Preparedness	Public Safety	Critical Infrastructure	Resilient Redevelop.	Stormwater Mgt.	Property Acquisition	
Low	1.	Walkway Rise (Area B2)	Engineering	Engineering; OEM	\$5,500,000	8+ years	FMA		x	x		x	
	2.	Public Health outreach and adaptation	Dir., Health/ Human	Dept. of Health/ Human Services; OEM	in-house	3-7 years	PDM, EMPG, NJ Dept. H	x	x				
	3.	Community Rating System involvement	Mayor's Office	Mayor's Office; OEM	\$95,000	3-7 years	CRS	x			x		
	4.	Hazard Mitigation Plan	Dir., OEM	OEM; Div. of City Planning	75000	3-7 years	EMPG, NOAA	x	x	x			



## Appendix

### Reference Materials

Reference material used to provide information incorporated into this Adaptation Master Plan includes the following:

1. *Visualizations of Adaptation Scenarios and Next Steps White Paper*, prepared by Michael Baker, Jr. Inc. for City of Jersey City, dated February 14, 2015.
2. *Sandy Recovery Strategic Planning Report - A Strategic Plan for Resilience*, prepared by City of Jersey City Planning Department, dated August 2014.
3. *Jersey City Stormwater Management Plan*, prepared by Malcolm Pirnie, Inc. for City of Jersey City, dated June 2005 and most recently amended August 2008.
4. *Hudson County Hazard Mitigation Plan*, Section 9.7 City of Jersey City, prepared by Tetra Tech, dated February 2015.
5. *Understanding the Flood Insurance Rate Maps – Jersey City Fact Sheet*, prepared by Hudson County Division of Planning.
6. *City of Jersey City, FEMA Preliminary Flood Insurance Rate Map*, revisions issued January 30, 2015.
7. *Jersey City Tree Canopy Assessment – A Report on Current Tree Canopy and Strategies for the Future*, prepared by Green Infrastructure Center, dated June 2015.
8. *The Green Guide - Increasing Sustainable Development in Jersey City's Redevelopment Areas*, prepared by Clark Caton Hintz and Pace Law School Land Use Law Center, dated March 2013.
9. *Booker T. Washington Housing Stormwater & Resiliency Master Plan*, prepared by Stantec, dated December 14, 2015.
10. *Collaborative Design and Dynamic Modeling for Urban Coastal Flood Adaption*, prepared by Davidson Laboratory, Stevens Institute of Technology, Jersey City Planning Department, Michael Baker, Jr., Inc., and New Jersey Sea Grant Consortium, dated May 2015

11. *Resilient Building Design Guidelines*, prepared by Princeton Hydro on behalf of the City of Hoboken, Hudson County, New Jersey, dated October 19, 2015.
12. *Resist Delay Store Recharge: A Comprehensive Urban Water Strategy*, prepared by Rebuild by Design, copyrighted 2014.
13. *State of New Jersey Hazard Mitigation Plan*, prepared by Tetra Tech, Inc., dated 2014.
14. *An Overview and Comparison of Navigable Storm Surge Barriers*, prepared by P.T.M Dircke, T.H.G. Jongeling, and P.L.M. Jansen, report not dated.
15. *Route 440/Routes 1&9T Multi-Use Urban Boulevard and Through Truck Diversion Concept Development Study Abstract and Executive Summary*, prepared for the City of Jersey City and prepared by Jacobs Engineering Group, Inc., dated May 2011.
16. *Morris Canal Greenway Plan*, prepared for the City of Jersey City and prepared by the RBA Group, dated May 2013.
17. *Mill Creek Initial Design + Finance Analysis and Recommendations*, prepared by Build it Green, dated September 23, 2016.

**Map of Prior Recommendations**

Source: *Visualizations of Adaptation Scenarios and Next Steps White Paper* (“The Baker Report”), prepared by Michael Baker International



Hydrological Analysis & Flood Illustrations

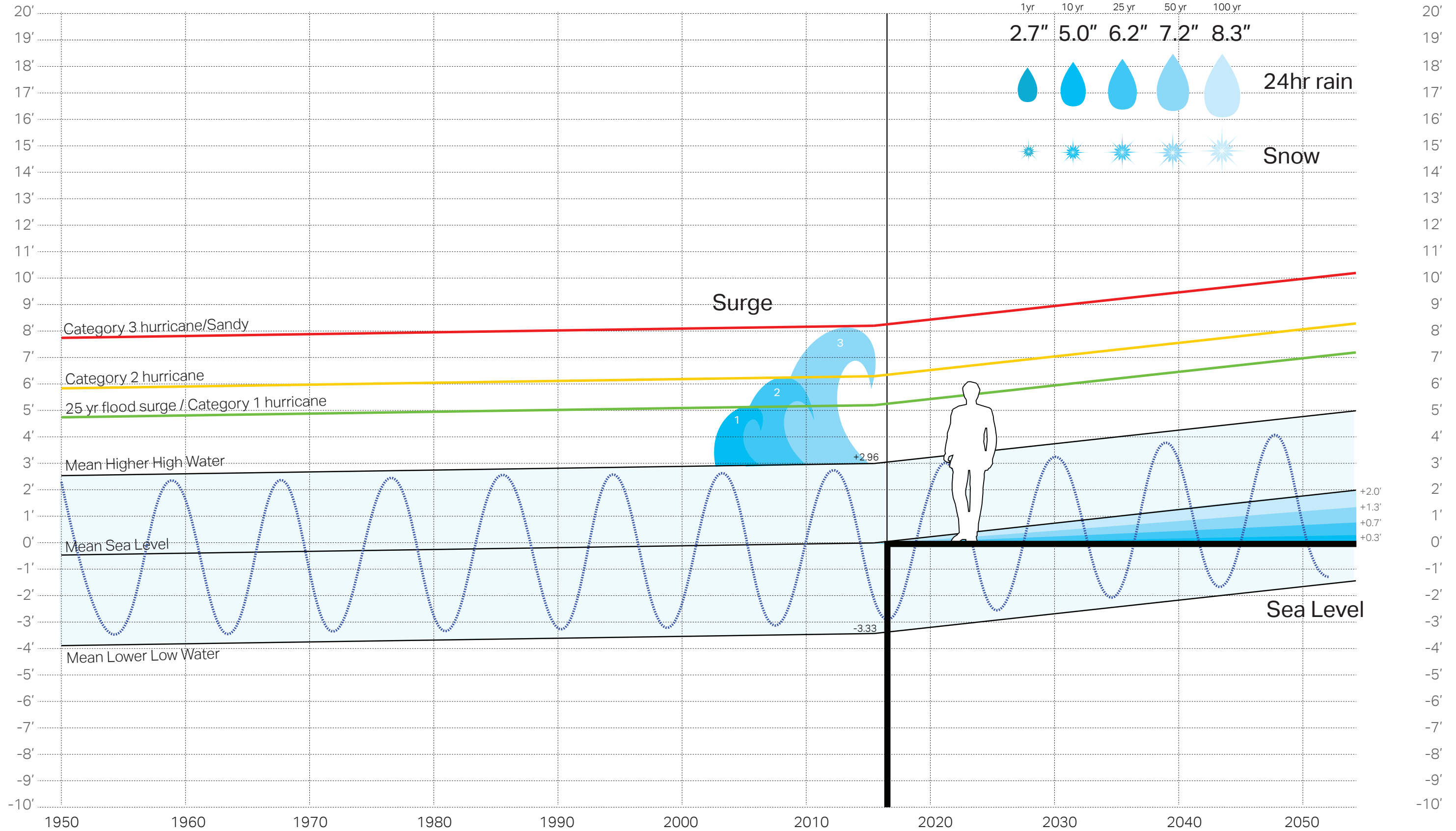
# **HYDROLOGICAL ANALYSIS AND ADAPTATION MEASURES**

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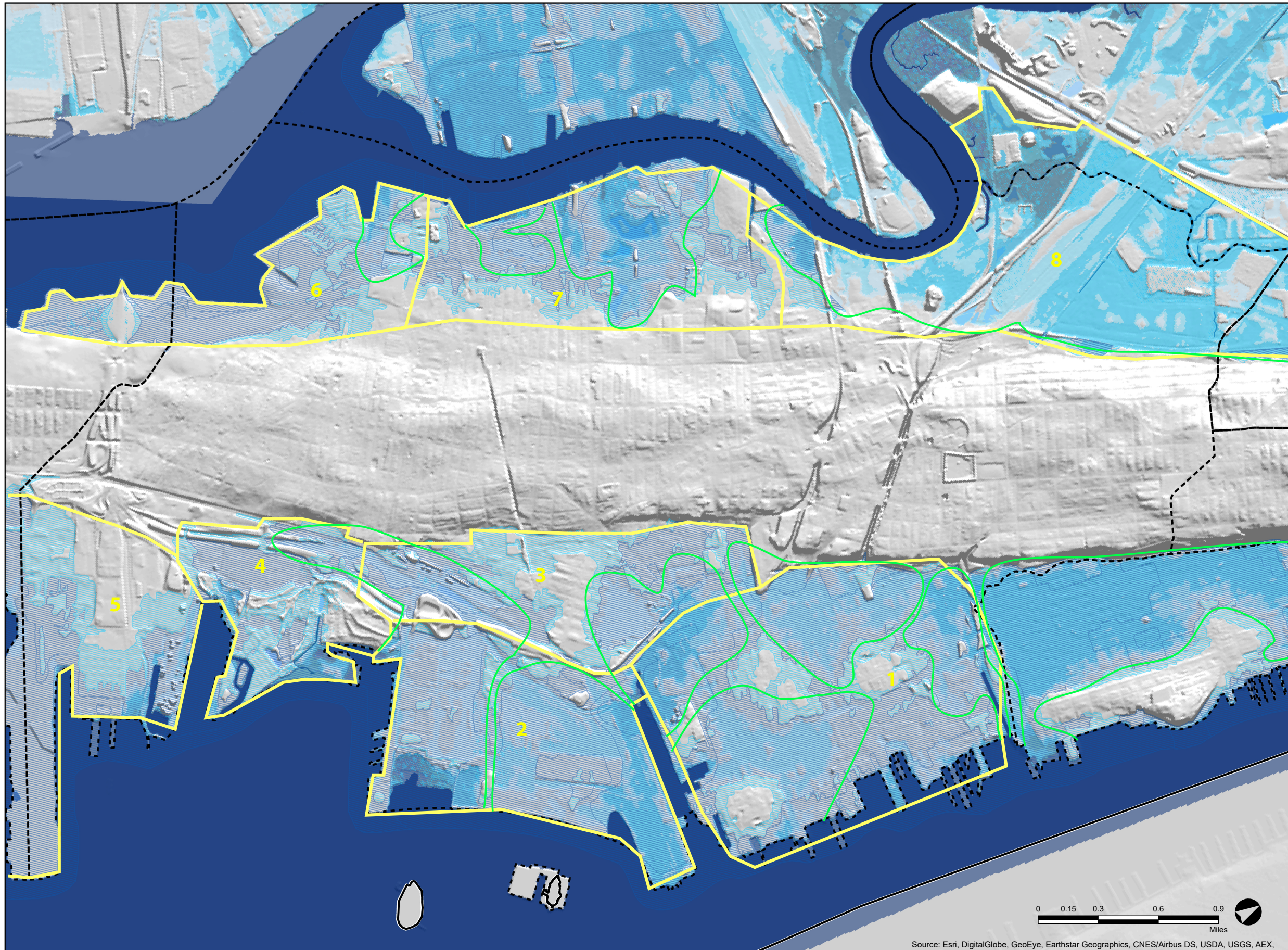
## **VISUALS APPENDIX**

**11.15.16 - updated**

# Exceedance Probability Levels and Tidal Datums - The Battery, NY, 2016



# MAP 1



## WATERSHED DISTRICTS

JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

#### Jurisdictional Boundaries

- State Border
- Municipal Border

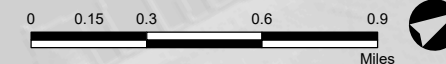
#### Water

- Wetlands
- Lower Hudson River Streams
- Lakes & Ponds
- Other Water Bodies
- 100-Year FEMA flood zone
- 500-Year FEMA flood zone
- Mean Sea Level
- +1 ft Sea Level Rise
- +2 ft Sea Level Rise
- +3 ft Sea Level Rise
- +4 ft Sea Level Rise
- +5 ft Sea Level Rise
- +6 ft Sea Level Rise

#### Hydrological Analysis

- Watershed Districts
- Sea Level Rise Sub-basins

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX,

# MAP 2

## COASTAL PROTECTION














JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

#### Jurisdictional Boundaries

-  State Border
-  Municipal Border

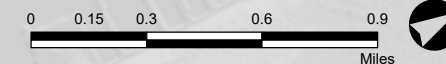
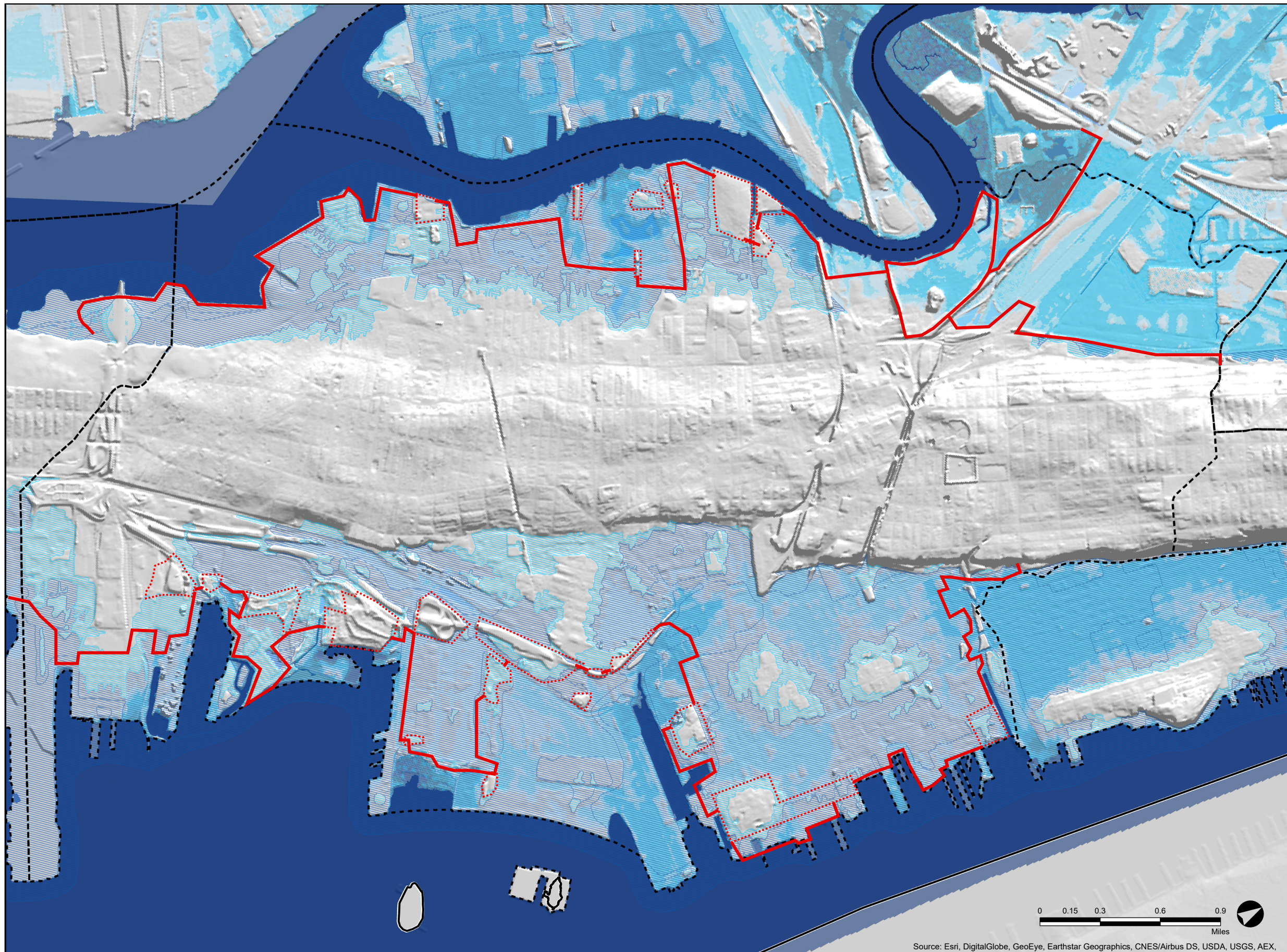
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-  Wetlands
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-  Lakes & Ponds
-  Other Water Bodies
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#### Hydrological Analysis

-  Lines of Protection
-  High ground anchors

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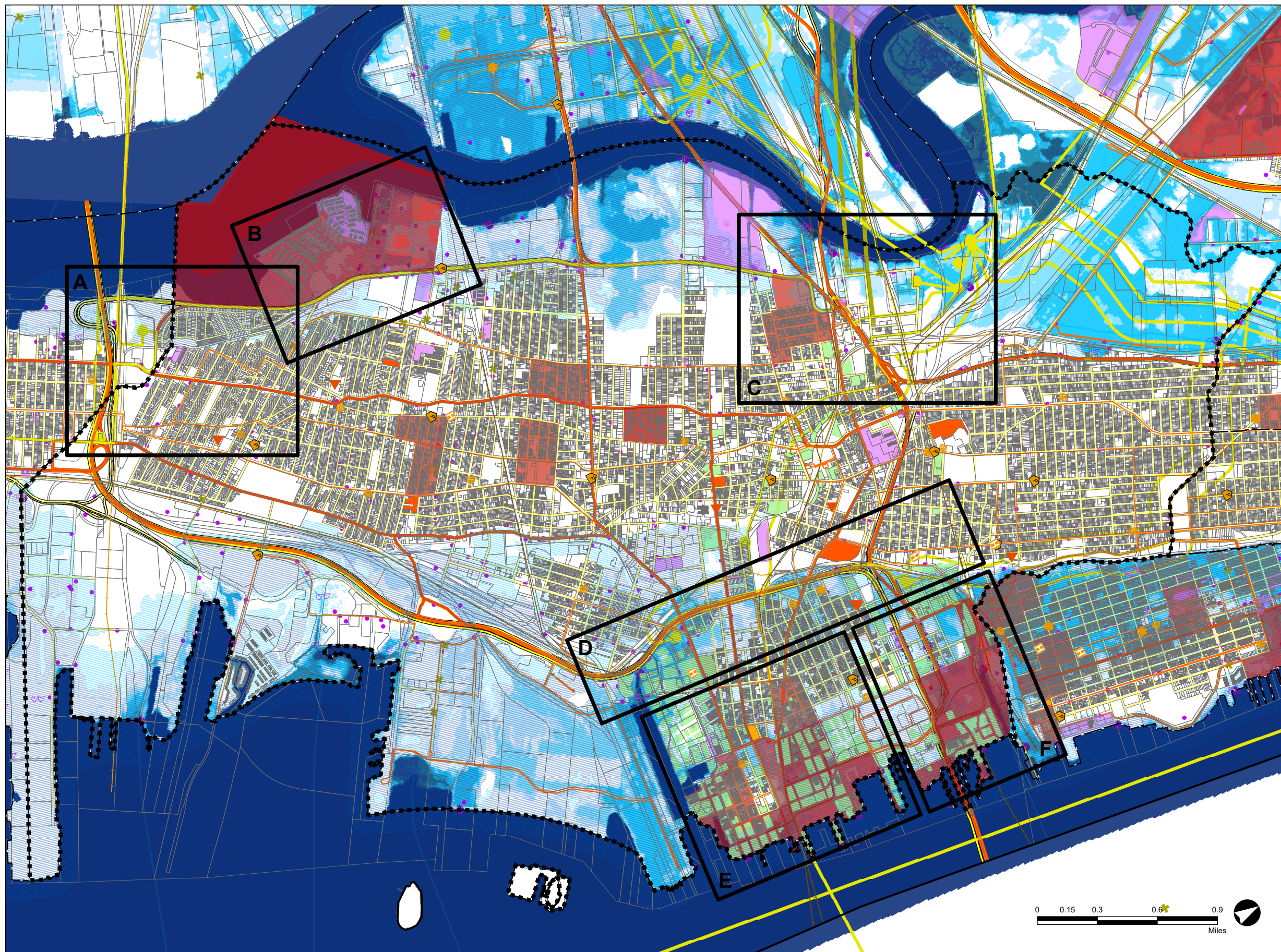
# MAP 3

## LAYERED VULNERABILITIES

JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

- Priority Areas
- Jurisdictional Boundaries**
- State Border
- Municipal Border
- Water**
- Wetlands
- Lower Hudson River Streams
- Lakes & Ponds
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- Emergency Medical Service
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- Nursing Home
- Senior Housing
- < 1.5 Std. Dev. Poverty Status
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- Approved, Built and Ongoing



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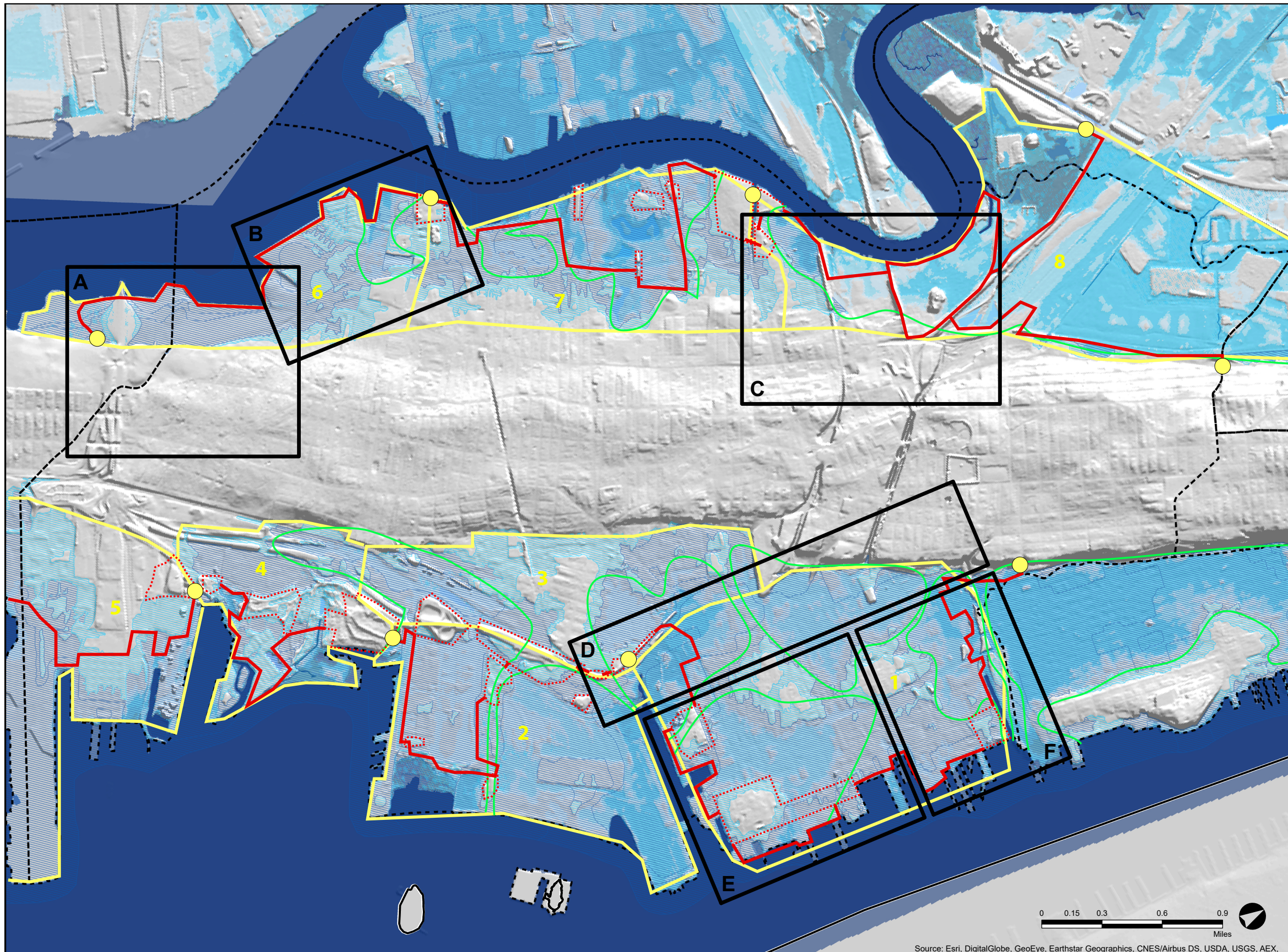
# MAP 4

## HYDROLOGICAL ANALYSIS

JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

-  Priority Zones
- Jurisdictional Boundaries**
-  State Border
-  Municipal Border
- Water**
-  Wetlands
-  Lower Hudson River Streams
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-  +5 ft Sea Level Rise
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- Hydrological Analysis**
-  Lines of Protection
-  Watershed Districts
-  Sea Level Rise Sub-basins
-  High ground anchors
-  Phasing points



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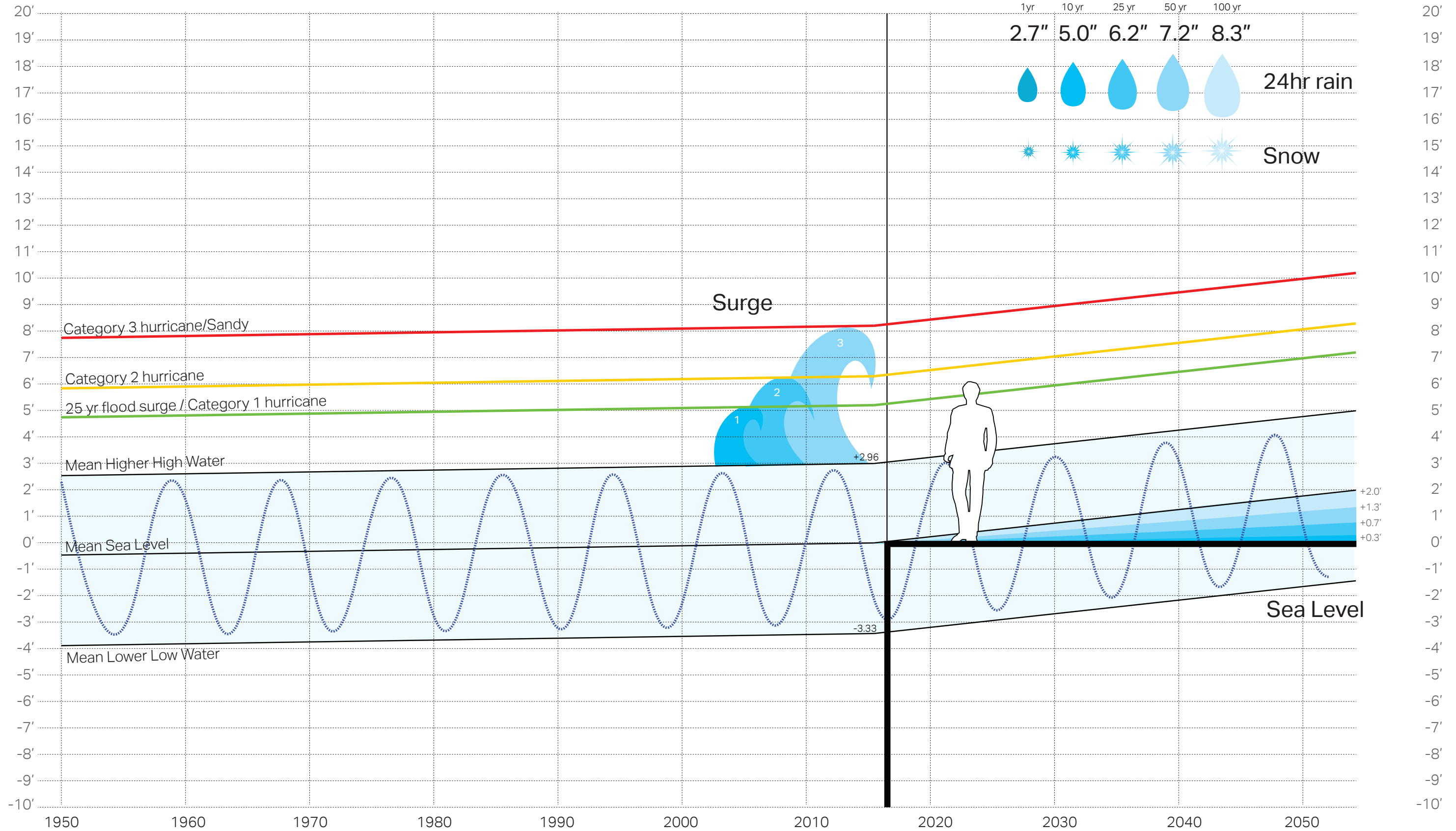
# **HYDROLOGICAL ANALYSIS AND ADAPTATION MEASURES**

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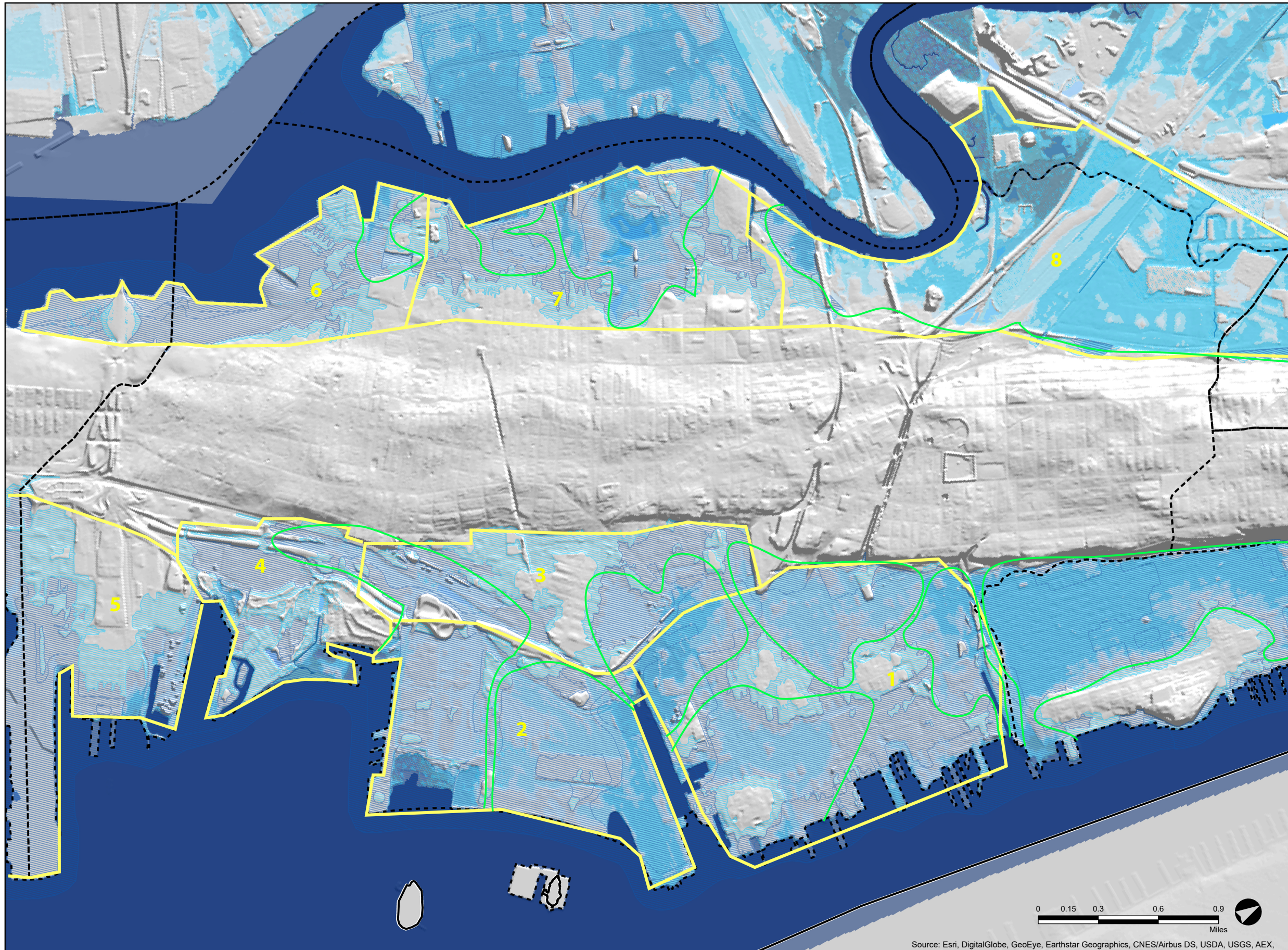
## **VISUALS APPENDIX**

**11.15.16 - updated**

# Exceedance Probability Levels and Tidal Datums - The Battery, NY, 2016



# MAP 1



## WATERSHED DISTRICTS




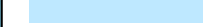









JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

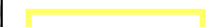

#### Jurisdictional Boundaries

-  State Border
-  Municipal Border

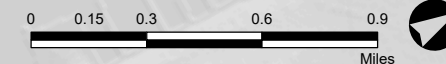
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# MAP 2

## COASTAL PROTECTION



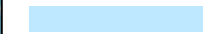










JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

#### Jurisdictional Boundaries

-  State Border
-  Municipal Border

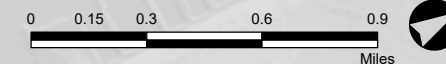
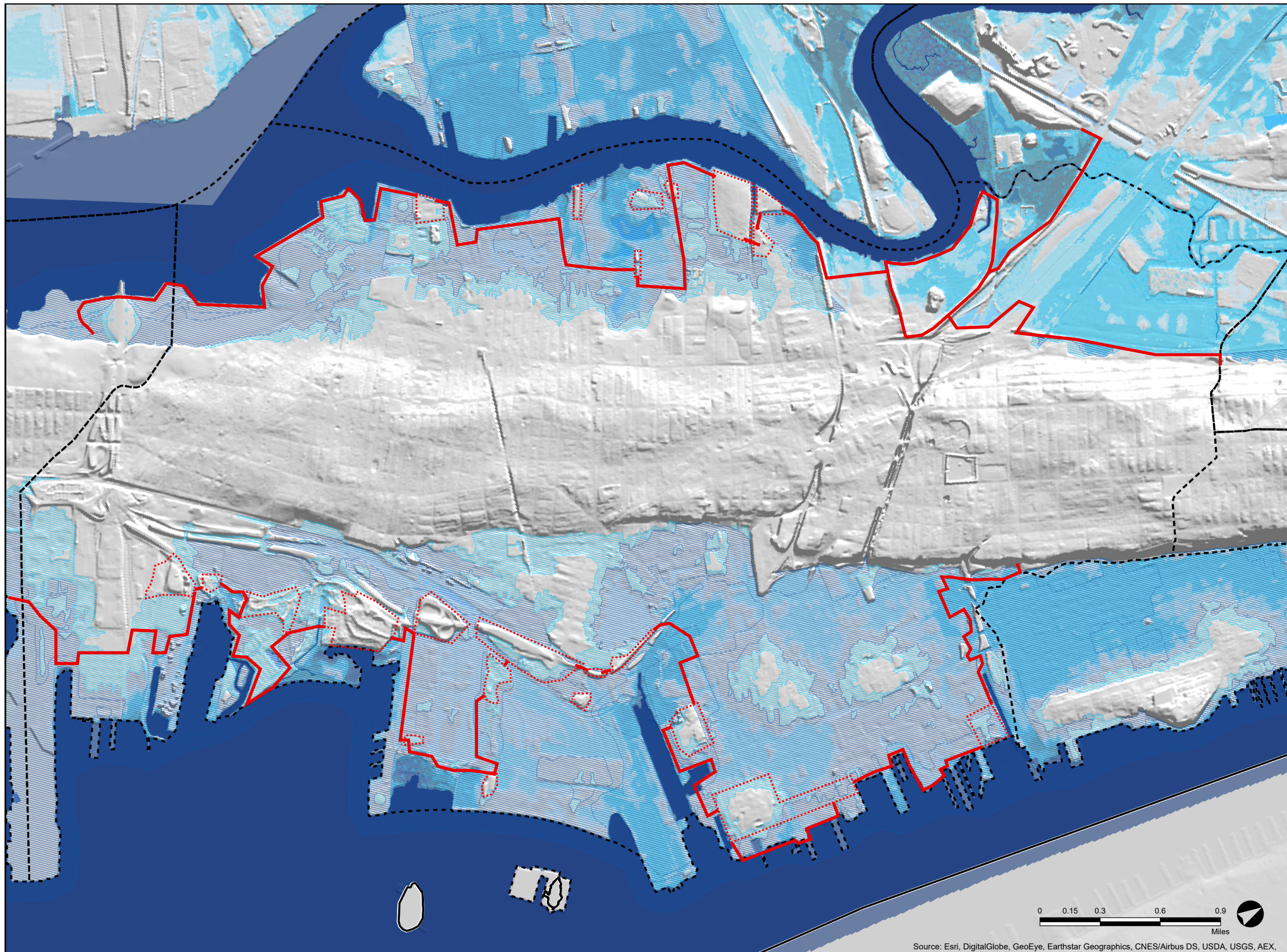
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-  Lines of Protection
-  High ground anchors

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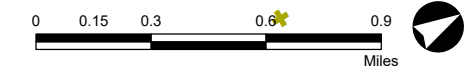
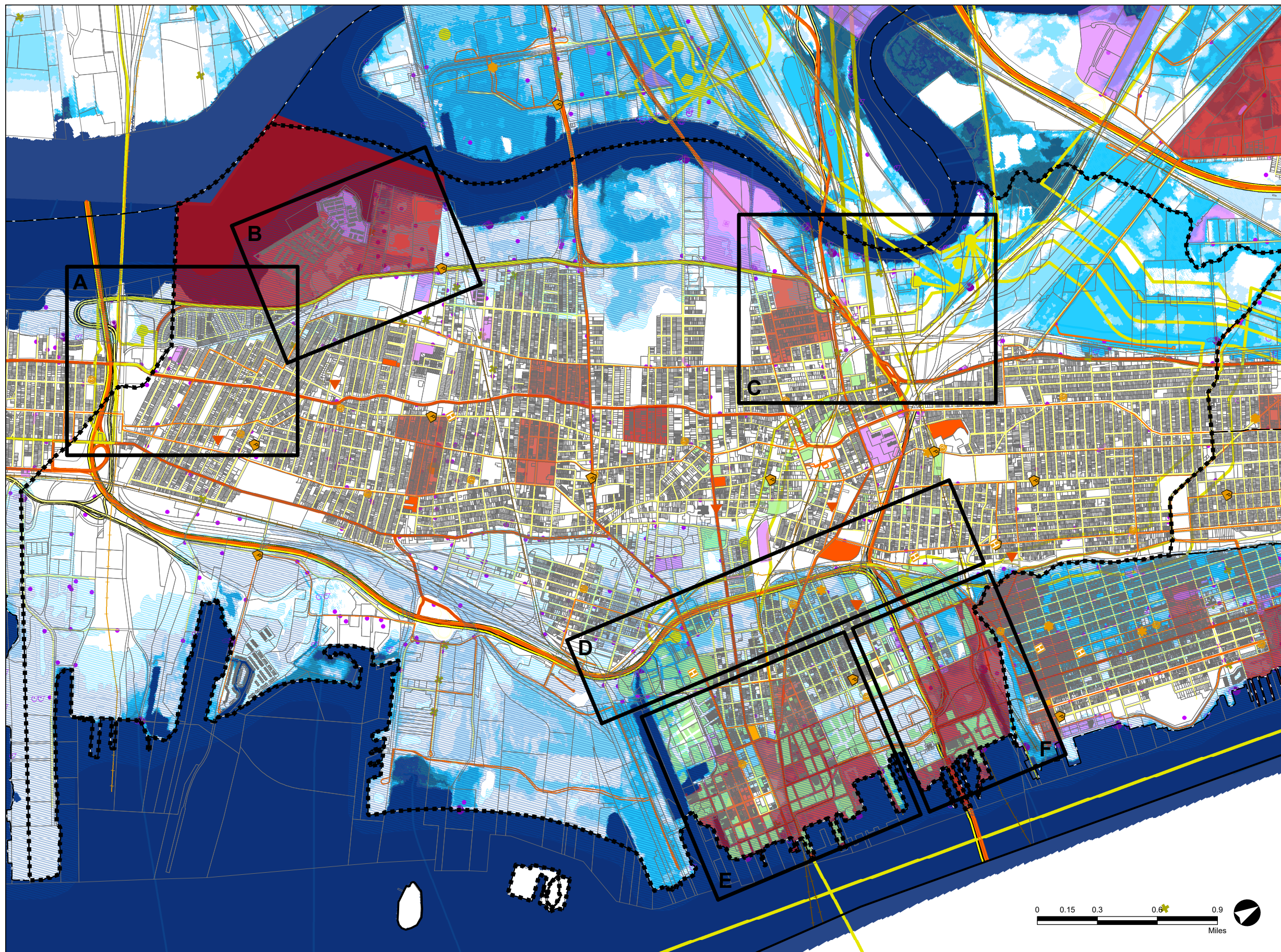
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JERSEY CITY  
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NEW JERSEY

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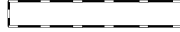


















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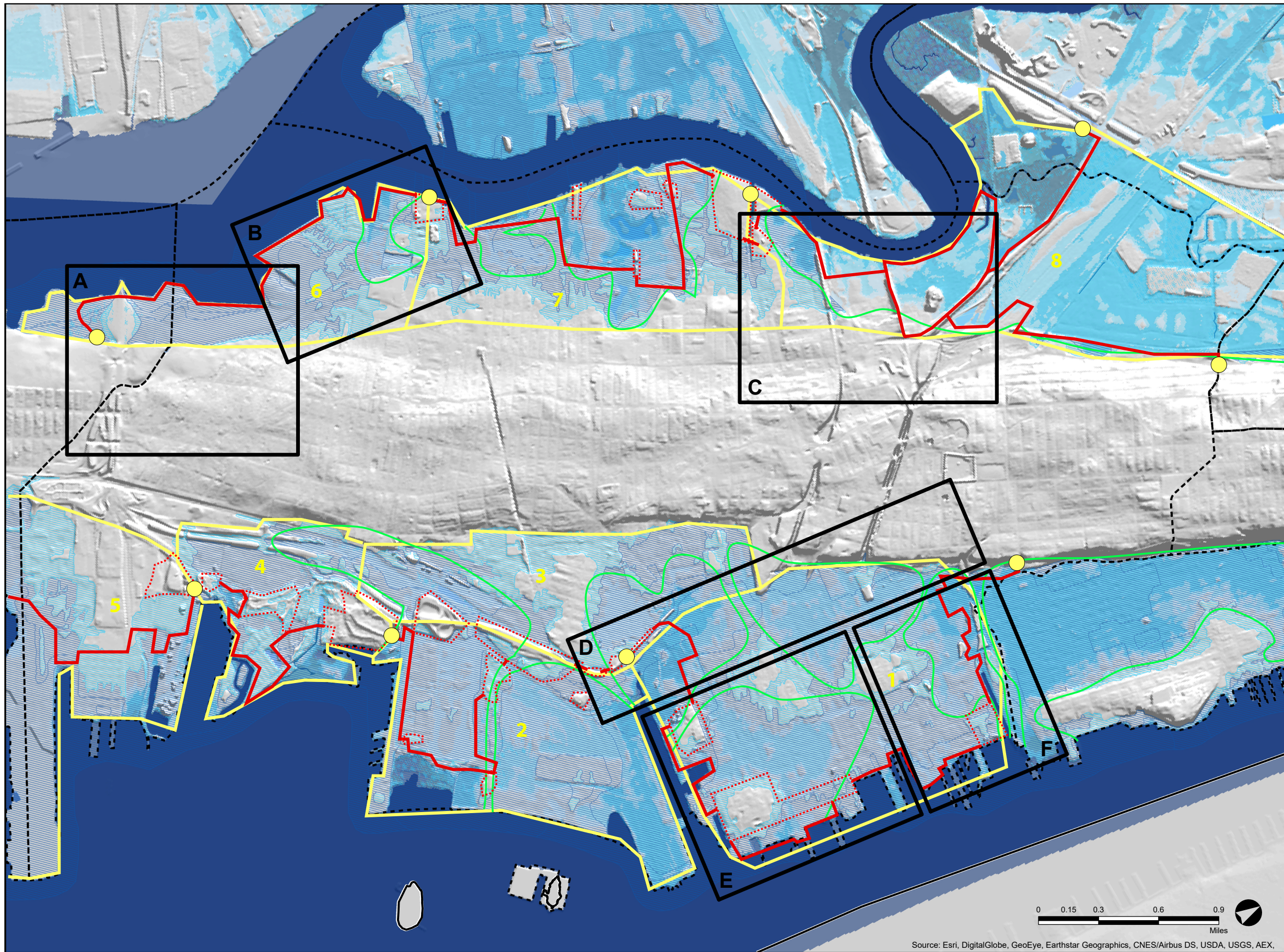
# MAP 4

## HYDROLOGICAL ANALYSIS

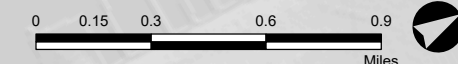
JERSEY CITY  
HUDSON COUNTY  
NEW JERSEY

### LEGEND

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